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REPORTS OF THE SWEDISH DEEP-SEA EXPEDITION 1947—1948

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HANS PETTERSSON

SCIENTIFIC LEADER OF THE EXPEDITION

VOLUME VII

Sediment Cores from the North Atlantic Ocean

FASC. I

GÖTEBORG
ELANDERS BOKTRYCKERI AKTIEBOLAG

REPORTS OF THE SWEDISH DEEP-SEA EXPEDITION. VOL. VII
SEDIMENT CORES FROM THE NORTH ATLANTIC OCEAN. NO. 1

NORTH ATLANTIC FORAMINIFERA

BY

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Summary

1. Foraminifera have been studied from 39 long deep-sea cores collected from low and mid latitudes in the North Atlantic. Modern Foraminifera populations have been studied from 53 undisturbed surface sediment samples collected with a short coring tube. Thirty planktonic species of Foraminifera and 123 species of benthonic Foraminifera are discussed and illustrated. Four of the benthonic species are described as new.

2. The deep-sea benthonic species are widely distributed in the cores indicating that the conditions influencing them on the ocean floor are essentially uniform.

3. The following distributions of planktonic species have been ascertained from the study of surface sediment samples:

   a. Species characteristic of low latitudes, less than 20° N Lat.: *Globorotalia menardii*, *G. tumida* and *Pulleniatina obliquiloculata*.

   b. Species which occur in greater abundance in low latitudes than in mid latitudes, although they occur at most stations: *Globigerina eggeri* and *Globigerinoides sacculifera*.

   c. *Globigerina pachyderma* is confined to high and mid latitudes.

   d. Species which are more abundant in mid latitudes but also occur in low latitudes: *Globigerina bulloides*, *G. inflata*, *Globorotalia hirsuta*, *G. scitula* and *G. truncatulinoides*.

   e. Species universally distributed in the samples: *Globigerinella aequilateralis*, *Globigerinita glutinata*, *Globigerinoides*

conglobata, G. rubra and *Orbulina universa.*

These distributions are tentatively correlated with distributions of sea surface isotherms.

4. The long cores contain layers of faunas normal for their latitudes alternating with faunas typical of a higher latitude. These are interpreted as representing alternating »warm» and »cold» epochs, and while a possible Pleistocene age is suggested for some of these, others are probably pre-Pleistocene. Correlation of these epochs appears possible in the mid-latitude cores, and may be possible elsewhere.

   A southward migration of the surface isotherms is indicated when the higher-latitude faunas were deposited; these faunal data also indicate that the tropical areas were cooler than at present.

5. Several cores contain shallow-water benthonic Foraminifera which have been displaced from shallow water. These are located relatively near areas of high submarine relief, such as islands and the coast of South America. These displaced faunas are associated with layers of sand. It is suggested that much of the mud in the deep ocean may be the finer fraction of sediments displaced from shoaler water.

6. Several fossil species are recorded from four cores; these fossils are believed to be Miocene in age. It is suggested that in two of these cores there has been more or less continuous deposition since the late Miocene.

7. *Globorotalia tumida* (*sensu strictu*) appears to extend back only to the last »cold» epoch, which is interpreted as late Pleistocene in age.

8. There is abundant evidence of the solution of the calcium carbonate of the Foraminifera tests in many samples, indicated by solution associated with broken specimens. Some species appear to be more resistant to solution than others and may remain where others have been destroyed. Benthonic species appear to be especially resistant to solution. The most intensive solution effects are seen in surface sediment samples from water depths greater than about 5 000 m., but there are exceptions: a large population is recorded from 7 500 m.

   Some cores have layers of broken specimens alternating with layers showing no evidence of solution. It is suggested that most solution may have occurred at the surface of the sediment and that variation in amount of solution is in part due to differences in rate of production of calcareous Foraminifera.

9. A mixed low- and mid-latitude modern planktonic fauna off Africa between approximately 15° and 20° N Lat. is attributed to mixing of tropical and mid-latitude water masses at the convergence of the Equatorial Counter Current and the Canaries Current. Mixed planktonic faunas are recognized from lower sections in cores off Africa between approximately 0° and 7° N Lat. This suggests that the convergence area has moved southward at various times during the past.

10. There appear to be marked differences in rate of deposition of sediment from place to place and time to time, according to the evidence from these cores.

Introduction

The development of the piston coring tube by Kullenberg (1947) has been an important advance in the study of sediments from the deep sea. This instrument obtains core samples which are consistently 10 to 15 m. long, and occasionally more than 19 m. long; whereas, the length of previous marine cores seldom has

exceeded 3 or 4 m. Collection of such relatively thick cross-sections of deep-sea sediment has increased the possibility of study of the recent history of the deep ocean basins, during the late, and possibly early, Tertiary.

This is one of several papers reporting on various aspects of the long submarine cores collected by the Swedish Deep Sea Expedition. The Foraminifera populations in 39 of the long cores collected from the Atlantic are reported. In addition, the Foraminifera populations in 53 samples of surface sediment from the North Atlantic have been analyzed.

Foraminifera have been demonstrated to be of considerable value in studying problems of paleoceanography. They are delicately adjusted to the various marine environments and they occur in considerable abundance in all parts of the oceans. They can be used to decipher environments of the geologic past if we know their ecologic distributions in the modern faunas and if it is assumed that the ecological adjustments were essentially similar during the past. There is relatively little reliable information on the ecology of this group, but there is sufficient to suggest certain broad relationships. Many of the conclusions of this study are based on the occurrence of planktonic Foraminifera, and knowledge of their ecology is especially inadequate, being based mostly upon their distribution in sediment samples rather than in plankton. In the present paper approximately 5,000 sediment samples mainly from long, deep-sea cores, have been studied quantitatively for Foraminifera. It is belived that this work has considerably increased our understanding of the ecology and the later Cenozoic distributions, especially of the planktonic types, but also of the benthonic types.

The purposes of this paper are as follows:

1. To analyze the distribution of modern, or near modern, Foraminifera contained in surface samples of deep-sea sediment, and to attempt a correlation with the known environmental conditions in this region.
2. To describe the vertical distributions of Foraminifera faunas in the cores and to attempt to interpret them from an ecological point of view.
3. To interpret the geologic ages represented by the different faunas in the cores.

The authors acknowledge with gratitude the generous cooperation of the members of Oceanografiska Institutet at Göteborg, and of the Swedish Deep Sea Expedition. Special thanks are due Professor Hans Pettersson, who provided this interesting material for study and who has assisted in numerous ways in facilitating the work. The senior author spent several days aboard the ALBATROSS as a guest of the Expedition. The present study was financed in large part by the United States Office of Naval Research (O. N. R. Project number NR 081 050). Several short cores used for study of the surface sediment were collected by the R/V ATLANTIS of the Woods Hole Oceanographic Institution and also by the USS SAN PABLO and USS REHOBETH of the U. S. Navy Hydrographic Office. The writers are grateful for this material which has been of great value in the present study.

Locations of Stations

The cores studied for this report come from the North and Equatorial Atlantic. The southernmost station is at 00° 13′ S. Lat. and the northernmost station is at 42° 27′ N. Lat. The stations are well-distributed in both the eastern and western areas. The shoalest stations occupied were two in the mid-Atlantic Ridge area at approximately 2,000 m.; the deepest station was in the Romanche Deep at approximately 7,500 m. The majority of stations are from water deeper than 4,000 m. The samples of surface sediment collected by the Swedish Deep Sea Expedition were taken at the positions of their long core stations. Loca-

Fig. 1. Locations of long cores.

tions of the long cores may be seen on Figure 1, and locations of all surface sediment samples used are plotted on Figure 2. Positions and depths of water are listed on Table 1.

Method of Study

The long, deep-sea cores were collected with the piston coring tube designed by Kullenberg (1947). The cores from the Atlantic vary from 0.5 m. to 19.3 m. in length, the average length being approximately 10 m. Twenty-two of the cores are considerably longer than 10 m. The cores were extruded aboard ship and the senior author had opportunity of examining three of these while they were being extruded and prepared for storage. All the Atlantic cores were examined three years after collection at Oceanografiska Institutet in Göteborg. It is the opinion of the senior author that the Kullenberg sampler obtains a representative section of sediment which has relatively little distortion throughout most of its length. The drag effect caused by the friction of the liner tube appears to be at a minimum for this type of sampling. The top section of any long core, however, is generally considerably disturbed; this is mainly due to the semi-fluid condition of the upper layers of sediment and because a long coring tube usually must be handled in

Fig. 2. Locations of surface sediment samples from short cores.

a horizontal position on board ship. A piston corer also tends to disturb the upper sediment, especially if the tube is not full and the piston is pulled upward during extraction of the instrument from the ocean floor.

Surface sediment samples were collected with the short coring tube described by Phleger (1951, p. 3). This gear obtains a relatively undisturbed surface sample which is emplaced in a plastic tube in the form of a short core. The plastic tube containing the core is handled and stored in an upright position to prevent mixing after collection. Surface samples were collected with this type of instrument at most of the coring stations occupied by the Swedish Deep Sea Expedition in the Atlantic, and this material supplements the upper sections of the cores. All the surface samples used for plotting distributions of modern Foraminifera were collected with this type of instrument.

The long cores were sliced vertically in the Göteborg laboratory. Samples for Foraminifera consisted of a horizontal slice of sediment 5 mm. in thickness taken from half sections of the cores. Approximately 3 mm. of material were trimmed from the outside of each sample to avoid faunal contamination caused by drag on the outside of the core. In general the samples were spaced 10 cm. apart throughout the length of each long core. This procedure was

TABLE 1.

Locations of Cores.

Core	Latitude	Longitude	Depth in meters
215	29° 55′ N	17° 32′ W	4320
217	27° 27′ N	19° 43′ W	4360
221	22° 31′ N	23° 28′ W	4940
223	20° 21′ N	20° 37′ W	3820
228	15° 53′ N	25° 27′ W	4280
229	13° 37′ N	25° 55′ W	4810
230	10° 12′ N	26° 36′ W	5500
232	07° 53′ N	24° 43′ W	4975
233	07° 13′ N	22° 38′ W	4125
234	05° 45′ N	21° 43′ W	3577
235	03° 12′ N	20° 28′ W	4560
236	02° 06′ N	20° 07′ W	5065
238	00° 07′ S	18° 12′ W	7315
239	00° 13′ S	18° 26′ W	7490
242	00° 30′ N	25° 38′ W	3620
243	00° 27′ N	27° 45′ W	3740
246	00° 48′ N	31° 28′ W	3210
248	00° 16′ N	33° 40′ W	4580
252	02° 10′ N	39° 06′ W	4480
254	04° 26′ N	41° 47′ W	4337
255	06° 17′ N	43° 20′ W	4490
257	07° 29′ N	45° 01′ W	4470
258	08° 15′ N	46° 30′ W	4554
261	12° 54′ N	52° 55′ W	5128
262	14° 32′ N	55° 05′ W	5480
263	15° 44′ N	56° 50′ W	5320
267	17° 47′ N	65° 14′ W	2105
276	33° 10′ N	50° 53′ W	4852
278	33° 16′ N	49° 00′ W	5520
279	34° 06′ N	46° 12′ W	4663
280	34° 57′ N	44° 16′ W	4256
281	34° 54′ N	44° 20′ W	4281
284	40° 32′ N	38° 17′ W	4257
288	41° 08′ N	31° 50′ W	2684
289	41° 12′ N	31° 30′ W	2640
290	41° 35′ N	29° 37′ W	1995
292	42° 16′ N	26° 36′ W	3216
293	42° 23′ N	26° 02′ W	3485
296	42° 27′ N	21° 08′ W	3736

Locations of Surface Sediment Samples.

Ship	Sample	Latitude	Longitude	Depth in meters
ALBATROSS	224 A	18° 50′ N	18° 24′ W	2810
	225 A	18° 44′ N	18° 44′ W	2973
	226 A	17° 57′ N	21° 03′ W	3100
	228 A	15° 53′ N	25° 27′ W	4280
	230 A	10° 12′ N	26° 36′ W	5500
	232 A	07° 53′ N	24° 43′ W	4975
	233 A	07° 13′ N	22° 38′ W	4125
	234 A	05° 45′ N	21° 43′ W	3577
	235 A	03° 12′ N	20° 28′ W	4560
	236 A	02° 06′ N	20° 07′ W	5065
	238 A	00° 07′ S	18° 12′ W	7315
	240 A	00° 59′ N	18° 37′ W	7500
	242 A	00° 30′ N	25° 38′ W	3620
	243 A	00° 27′ N	27° 45′ W	3740
	246 A	00° 48′ N	31° 28′ W	3210
	247 A	00° 15′ N	33° 37′ W	4285
	252 A	02° 10′ N	39° 06′ W	4480
	257 A	07° 29′ N	45° 01′ W	4470
	258 A	08° 15′ N	46° 30′ W	4554
	261 A	12° 54′ N	52° 55′ W	5128
	265 A	16° 51′ N	58° 21′ W	5832
	267 A	17° 47′ N	65° 14′ W	2105
	269 A	24° 19′ N	63° 26′ W	5855
	270 A	28° 05′ N	60° 49′ W	5760
	272 A	29° 21′ N	58° 09′ W	5450
	279 A	34° 06′ N	46° 12′ W	4663
	280 A	34° 57′ N	44° 16′ W	4256
	281 A	34° 54′ N	44° 20′ W	4281
	283 A	37° 37′ N	41° 41′ W	4940
	284 A	40° 32′ N	38° 17′ W	4257
	285 A	40° 34′ N	35° 52′ W	4570
	286 A	40° 41′ N	34° 58′ W	4060
	288 A	41° 08′ N	31° 50′ W	2684
	289 A	41° 12′ N	31° 30′ W	2640
	292 A	42° 16′ N	26° 36′ W	3216
	294 A	41° 04′ N	24° 16′ W	3749
	297 A	43° 04′ N	19° 40′ W	5980
ATLANTIS	4631	31° 15′ N	41° 30 W	1832
	4633	32° 28′ N	30° 04′ W	3245
	4635	34° 35′ N	16° 11′ W	3610
	4637	35° 22′ N	10° 23′ W	4181
	4736	34° 10′ N	10° 30′ W	4420
	4739	30° 06′ N	17° 26′ W	4363
	4740	26° 36′ N	30° 09′ W	5323
	4741	25° 13′ N	41° 32′ W	4524
	4742	27° 25′ N	50° 23′ W	5133
	4743	30° 37′ N	59° 07′ W	5531
SAN PABLO	3—16	31° 53′ N	20° 54′ W	4755
	3—47	43° 51′ N	29° 07′ W	3017
REHOBETH	3—29	53° 57′ N	32° 02′ W	2761
	3—32	47° 24′ N	30° 03′ W	3383
	3—38	36° 34′ N	38° 15′ W	3109
	3—41	35° 45′ N	51° 22′ W	4602

occasionally modified where stratigraphic changes could be observed. In the short cores a surface sample was taken 1 cm. in thickness.

The samples were prepared for study by washing with a water spray on a brass sieve having an opening of 0.074 mm. which retains all the adult Foraminifera and all of the juvenile forms except the smallest stages. Smaller Radiolaria, diatoms, coccoliths, and other forms of similar size are not retained.

In study of the dried samples only the fraction retained on a brass sieve having an average opening of 0.149 mm. was examined. Essentially all the larger forms, presumably adults, were retained on this sieve.

Each sample was examined in detail, beginning with the top sample in each core. A species count was made of the top sample and of each succeeding sample lower in the core where any faunal differences from the previous population could be detected. Where there were no faunal differences through several samples, at least each fifth sample was counted. Samples containing more than about 800 planktonic specimens were quartered, using the device described by Parker (1948, p. 218). No less than about 300 planktonic specimens were counted in each sample where sufficient specimens were present. In most samples all the benthonic specimens were counted due to their relative rarity. Occurrences of species are listed as percentages of total populations, and the faunal data for each sample are divided into a planktonic and a benthonic group. The percentage occurrences are listed separately for both groups so that each constitutes 100 %; this is the only valid quantitative treatment of Foraminifera from an ecological point of view. Total populations were estimated for each sample exclusive of the small forms not retained on the 0.149 mm. sieve.

Several additional observations were made on each sample. An estimate of the percentage of broken shells of Foraminifera was made, the presence of Radiolaria and other skeletal remains and the occurence of sand, volcanic materials and any unusual minerals was recorded.

One of the problems in study of submarine sediment cores is the relatively small amount of sediment available. In study of land geology, exposures in some places are sufficient to obtain a three-dimensional view of materials, but this is impossible at the present time in submarine geology. The piston coring tube obtains a cross-section which is only about 2 inches in diameter, and the small coring tube sample has a diameter of 1—3/8 inches. This material is assumed to be representative of a much larger area, although this assumption is not necessarily true in any absolute sense. This qualification should be kept in mind in evaluating the quantitative data on distribution of Foraminifera in the samples studied.

Another problem in ecological study of Foraminifera from sediment samples is that of obtaining samples of equivalent sizes, as well as methods of presenting the data. Said (1950) in his study of samples from the Red Sea has adopted the system proposed by Schott (1935) in his extensive study of deep-sea cores from the equatorial Atlantic, although Schott did not use it in his plots of distributions. According to this method, occurrences of species are given as numbers of specimens per gram (dry weight) of sediment. This is called the »foraminiferal number».

The principal advantage of this method is that the results may be more comparable to the present occurrences in essentially dry rocks deposited during the geologic past. The principal difficulty of using the »foraminiferal number» is that there is no common arithmetic base for comparison of the numbers. This makes it almost impossible to compare the species composition of different faunas without tedious manipulation of the data. Moreover, the use of a standard size of sample based upon dry weight seems to be an artifical measure for ecological purposes. This

criticism is more applicable to ecologic studies of the modern and near-modern faunas than to studies of vertical distribution of faunas in cores, which was the main emphasis in Schott's 1935 study.

The procedure adopted by the writers is to use volume and area as a measure of size of sample. In any ecological study it appears that area is an important measure which must be considered, and this is especially true when dealing with benthonic populations. The use of a coring tube for sampling sediment will obtain a constant area of sediment if reasonable care is exercised in the operation. It is suggested that the living space of a population is also three-dimensional. At and near the surface of the sediment the sea water constitutes an integral part of the living space. It is suggested that volume and area may be a more reliable measure for ecological study of Foraminifera than the dry-weight measure. To use this method, however, the sediment should have essentially its original water content, which is largely a problem in proper handling and storage of samples. 110 of the present samples selected at random were weighed before washing; these gave an average weight of approximately 3 grams. It is suggested that this may be taken as an average weight of the samples studied, all of which were of uniform volume in their original condition. The occurrence data presented can therefore be converted into »foraminiferal number» if this is desired.

The Foraminifera Species

Planktonic Species

The following discussion is concerned chiefly with the identification of the planktonic species and their reported distribution in the literature. The distributions listed cover only occurrences reported in the North Atlantic and occasionally in related areas. The distribution in the Swedish Deep Sea Expedition cores and surface samples is discussed in detail elsewhere. The references used are included in the synonymies under each species. In many cases it was possible to check these by an examination of the types. This was true for almost all American publications and a few others whose authors had deposited types at the U. S. National Museum in Washington. In most other cases, figures were given which were studied carefully. It is believed that the synonymies truly represent the species as we have identified them. This includes the fossil forms, also. In no case, except for an occasional reference such as that of Schott (1935) where no figures were given, are references included in the synonymy because a species is identified by the same specific name.

A few species occurring near the bottom of several cores are believed to be at least pre-Pliocene in age. These include: *Globigerina altispira* Cushman and Jarvis, *G. venezuelana* Hedberg, *Sphaeroidinella rutschi* Cushman and Renz (which may also include *S. seminulina* Schwager) and probably *Globorotalia* sp. 2 and *G. multicamerata* Cushman and Jarvis. A study of the literature shows that these species, exclusive of *Globorotalia* sp. 2 and possibly *G. multicamerata*, have an overall common occurence from the Upper Oligocene to the Middle Miocene in the general West Indian — Caribbean region. Further discussion of these fossil species and their significance in the cores will be given later in the section on the interpretation of core faunas as well as in the species discussions.

Sphaeroidina bulloides d'Orbigny

(Plate 1, figure 5)

Sphaeroidina bulloides d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 267, no. 1; Modèles, no. 65.

This species is reported from Brazil to Cape Cod with its highest frequency between Cape Cod and Cape Hatteras. Parker (1948) reports

it on the continental shelf of the northeastern United States south of Cape Cod with frequencies of less than 1 % in most cases except in samples shallower than 250 m. where it may form as much as 15 % of the planktonic fauna.

Although the species is found in small numbers in the cores it does not occur in the surface samples with significant frequencies. It is questionable whether or not it is a planktonic species and therefore it is listed in that group in Tables 2—37 in brackets. In all cases it forms a very small part of the total planktonic fauna. The findings of Parker given above point to the strong probability that this is a benthonic form, which is the opinion of most authors. It has not, as far as can be ascertained, been observed in plankton tows.

Globigerina altispira Cushman and Jarvis

(Plate 1, figures 1, 2, 6)

Globigerina altispira Cushman and Jarvis, 1936, Contr. Cushman Lab. Foram. Res., vol. 12, pt. 1, p. 5, pl. 1, figs. 13, 14. — Bermudez, 1949, Spec. Publ. 25, Cushman Lab. Foram. Res., p. 277, pl. 21, fig. 43.

This species appears to be related to *G. eggeri* Rhumbler but has a much higher spire. It is reported from the Bowden Marl of Jamaica by Cushman and Jarvis and from the Miocene and Upper Oligocene of the Dominican Republic by Bermudez, the chief occurrence being in the Middle Miocene Gurabo Formation which is correlated with the Bowden Marl. The specimen figured by Coryell and Rivero (1940, p. 339, pl. 42, fig. 31) from the Miocene of Port-au-Prince, Haiti appears to belong here also. They correlate this formation tentatively with the Bowden marl but believe that it represents a deeper water deposit. The specimen figured by Dorsey (1948, p. 313, pl. 38, fig. 3) from the Calvert Formation of Maryland probably does not represent this species. The species has also been recorded by Colom (1946, p. 56, pl. 3, figs. 69, 73, 74) from the Burdigalian of the Balearic Islands, Spain, but these figures have not been seen. The specimens figured by Cushman and Todd (1945, p. 66, pl. 11, figs. 11, 12) from the Miocene of Buff Bay, Jamaica, should be referred to *G. venezuelana* Hedberg.

The range established for this species at the present time is from the Upper Oligocene to the Upper Miocene. It appears to occur most abundantly in the Middle Miocene as exemplified by the Bowden marl of Jamaica, the Port-au-Prince beds of Haiti and the Gurabo Formation of the Dominican Republic.

Globigerina bulloides d'Orbigny

(Plate 1, figures 3, 4, 7, 8)

Globigerina bulloides d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 277, no. 1; Modèles no. 76; and young, no. 17. — H. B. Brady, 1884, Rep't. Voy. CHALLENGER, Zool., vol. 9, p. 593, pl. 77; pl. 79, figs. 1—7 (Fig. 5 may represent *Globigerinoides rubra*). — Cushman, 1924, Bull. 104, U. S. Nat. Mus., p. 7, pl. 2, figs. 1—4 (questioned in explanation of plate but figures appear to represent this species). — Schott, 1935, Wiss. Ergeb. deutsch. Atlantisch. Exped. Forsch. Vermess. »Meteor» 1925—1927, vol. 3, pt. 3, Sect. B, p. 59. — Phleger, 1939, Bull. Geol. Soc. America, vol. 50, pl. 3, figs. 15, 16; 1942, ibid., vol. 53, p. 1087. — Cushman and Henbest, 1940, U. S. Geol. Surv. Prof. Paper 196—A, pt. 2, p. 46, pl. 8, figs. 2 a—c. — Parker, 1948, Bull. Mus. Comp. Zool., vol. 100, no. 2, pl. 7, figs. 1, 2. — Ovey, in Wiseman and Ovey, 1950, Proc. Geol. Assoc., vol. 61, pt. 1, p. 65, pl. 2, figs. 3 a—c. — Phleger, 1951, Mem. 46, Geol. Soc. America, pt. 1, p. 68; Phleger and Parker, 1951, ibid., pt. 2, p. 34, pl. 19, figs. 6, 7.

This species is listed from the Arctic by authors but there is no specific data on frequencies. It is recorded from Lat. 60 ° N

with a frequence of 18 %; southwest of the British Isles 28 %; between this point and Newfoundland abundant; on the continental shelf and slope of northeastern United States south of Cape Cod 50 %, although the general average is lower than this; in the Gulf of Mexico 10—20 %; off the African coast from Lat. 0—20 ° N it varies from ± 1 % to the south to 10+ % to the north.

Globigerina digitata H. B. Brady

(Plate 1, figures 9, 10)

Globigerina digitata H. B. Brady, 1879, Journ. Micr. Sci., vol. 19, p. 72; 1884, Rep't. Voy. CHALLENGER, Zool., vol. 9, p. 599, pl. 80, figs. 6—10; pl. 82, figs. 6, 7.

This species is reported to be rare in the North and South Atlantic. It is not found with significant frequencies in surface samples.

Globigerina eggeri Rhumbler

(Plate 1, figures 11, 12)

Globigerina dubia H. B. Brady (not Egger, 1857), 1879, Quart. Journ. Micr. Sci., vol. 19, n. ser., p. 71; 1884, Rep't. Voy. CHALLENGER, Zool., vol. 9, p. 595, pl. 79, figs. 17 a—c; — Cushman, 1924, Bull. 104, U. S. Nat. Mus., pt. 5, p. 8, pl. 2, figs. 5—8. — Schott, 1935, Wiss. Ergeb. deutsch. Atlantisch. Exped. Forsch. Vermess. »Meteor» 1925—1927, vol. 3, pt. 3, Sect. B, p. 59. — Phleger, 1939, Bull. Geol. Soc. America, vol. 50, p. 1404, pl. 1, figs. 14, 15. — Ovey, in Wiseman and Ovey, 1950, Proc. Geol. Assoc., vol. 61, pt. 1, p. 67, pl. 3, figs. 10 a, b.

Globigerina eggeri Rhumbler, 1900, Nordische Plankton, pt. 14, Foraminiferen, p. 19, text. figs. 20 a—c. — Parker, 1948, Bull. Mus. Comp. Zool., vol. 100, no. 2, pl. 7, figs. 5, 6. — Phleger, 1951, Mem. 46, Geol. Soc. America, pt. 1, p. 68; Phleger and Parker, 1951, ibid., pt. 2, p. 34, pl. 19, figs. 8, 9.

Globigerina conglomerata Cushman (not Schwager, 1866), 1941, Amer. Journ. Sci., vol. 239, pl. 1, fig. 3. — Phleger, 1942, Geol. Soc. America, vol. 53, p. 1087.

The species as defined here has little variation except for the specimens from the more northern cores. These specimens are smaller than those figured but otherwise maintain the characteristics of the species. Ovey points out that his species »*G. dubia*» varies from forms referable to *G. subcretacea* Lomnicki to *G. eggeri* Rhumbler. There are no specimens referable to the former species in our North Atlantic material. Pacific specimens kindly sent by Miss Ruth Todd have been used for study. They show a low-spired form with an average of 6 chambers in the last-formed whorl. *G. eggeri* usually has 5 chambers. The figures given by Ovey show a form identical with our species.

This species is recorded as far north as Lat. 60° N where it is rare. It has a frequency of 6 % southwest of the British Isles; highest frequencies of about 50 % occur along the continental shelf of northeastern United States south of Cape Cod; eastward on the slope the frequencies drop to between 10 % and 20 %. It is of interest to note that the species was not recorded by Cushman and Henbest in the cores taken across the Atlantic between Newfoundland and the British Isles. In the Gulf of Mexico the frequencies vary between 5 % and 20 %. Similar frequencies are found off the African coast between Latitudes 0° and 20° N. In general the species is reported in significant numbers between Latitudes 0° and 50° N with the highest frequencies between 20° and 40° N.

Globigerina hexagona Natland

(Plate 1, figures 13, 14)

Globigerina hexagona Natland, 1938, Bull. Scripps Instit. Ocean., Techn. Ser., vol. 4, no. 5, p. 149, pl. 7, figs. 1 a—c.

The specimens were compared to the holotype and found to be identical. This species

has not previously been reported from the Atlantic. It is not found in significant numbers in surface samples but occurs in cores between Lat. 0° and 20° N with one or two rare occurrences farther north. The species was described from 884 m. off the coast of southern California and Natland states that it was found only in his deeper samples in the area.

Globigerina inflata d'Orbigny

(Plate 1, figure 15, 16)

Globigerina inflata d'Orbigny, 1839, in Barker-Webb, and Berthelot, Hist. Nat. Îles Canaries, vol. 2, pt. 2, »Foraminifères», p. 134, pl. 2, figs. 7—9. — H. B. Brady, 1884, Rep't. Voy. CHALLENGER, Zool., vol. 9, p. 601, pl. 79, figs. 8—10. — Schott, 1935, Wiss. Ergeb. deutsch. Atlantisch. Exped., Forsch. Vermess. »Meteor», 1925—1927, vol. 3, pt. 3, Sect. B, p. 59. — Cushman, 1924, Bull. 104, U. S. Nat. Mus., pt. 5, p. 12, pl. 3, figs. 1—3. — Phleger, 1939, Bull. Geol. Soc. America, vol. 50, pl. 3, figs. 18, 19; 1942, ibid., vol. 53, p. 1087. — Cushman and Henbest, 1940, U. S. Geol. Surv. Prof. Paper 196—A, pt. 2, pl. 8, fig. 4. — Parker, 1948, Bull. Mus. Comp. Zool., vol. 100, no. 2, pl. 6, figs. 12, 13. — Ovey, in Wiseman and Ovey, 1950, Proc. Geol. Assoc., vol. 61, pt. 1, p. 66, pl. 2, figs. 5 a—c. — Phleger, 1951, Mem. 46, Geol. Soc. America, pt. 1, p. 68; Phleger and Parker, 1951, ibid., pt. 2, p. 34, pl. 19, figs. 10, 11.

Globorotalia punctulata Cushman and Bermudez (not d'Orbigny, 1826), 1949, Contr. Cushman Lab. Foram. Res., vol. 25, pt. 2, p. 42, pl. 8, figs. 7—9.

Brady gives an over-all distribution of this species in the Atlantic from 82° 27′ N to 53° 55′ S. It occurs with a frequency of 5 % at Lat. 60° N. This increases to 54 % southwest of the British Isles. It is listed as common to abundant between this point and Newfoundland. On the western Atlantic continental shelf and slope off the United States south of Cape Cod it ranges from 10—20 % on the shelf to 50 % on the slope. In the Gulf of Mexico it is very rare and is found east of Cuba with a frequency of 0.6 %. Off the coast of Africa between Latitudes 0° and 20° N it ranges from ±1 % in the south to 20+ % in the north. This gives a range of high frequency from 50° N to about 20° N excluding the Gulf of Mexico. The highest known frequencies reported are from north of Latitude 35° N.

Globigerina pachyderma (Ehrenberg)

(Plate 1, figures 17, 18, 19)

Aristerospira pachyderma Ehrenberg, 1861, Monats. k. preuss. Ak., Wiss. Berlin, p. 303; 1872 (1873) Abhandl. Ak. k. Wiss. Berlin, pl. 1, fig. 4.

Globigerina pachyderma (Ehrenberg), Phleger, 1939, Bull. Geol. Soc. America, vol. 50, pl. 2, figs. 1, 2; 1942, ibid., vol. 53, p. 1087. — Cushman and Henbest, 1940, U. S. Geol. Surv. Prof. Paper 196—A, pt. 2, pl. 8, fig. 1. — Ovey, in Wiseman and Ovey, 1950, Proc. Geol. Assoc., vol. 61, pt. 1, p. 65, pl. 2, figs. 2 a—c. — Phleger, 1951, Mem. 46, Geol. Soc. America, pt. 1, p. 73; Phleger and Parker, ibid., pt. 2, p. 35, pl. 19, figs. 12, 13.

This species as defined here may include some forms listed by authors as *G. dutertrei* d'Orbigny. That species has been interpreted by Brady (1884, p. 601) as a typical Antarctic species and this interpretation has been followed by a number of authors. As the species was originally described by d'Orbigny from the vicinity of Cuba it seems unlikely the Antarctic and Arctic species is referable to it.

G. pachyderma is not reported south of Lat. 20° N in the North Atlantic. It occurs at Lat. 60° N with a frequency of 72 % decreasing to 0.8 % southwest of the British Isles. Westward from this point it is listed as abund-

ant to common in some samples, less frequently in others. On the continental slope off the United States it ranges from 0—5 %. It is reported east of Cuba with a frequency of 0.08 %.

Globigerina quinqueloba Natland

(Plate 1, figures 20, 21)

Globigerina quinqueloba Natland, 1938, Bull. Scripps Instit. Ocean., Techn. Ser., vol. 4, no. 5, p. 149, pl. 6, figs. 7 a—c.

The Atlantic specimens are identical with the holotype. The species has not been reported in the Atlantic. Natland reports it in the Pacific ranging from off Panama to off Long Beach, California.

Globigerina venezuelana Hedberg

(Plate 1, figures 24, 25)

Globigerina venezuelana Hedberg, 1937, Journ. Pal., vol. 11, no. 8, p. 681, pl. 92, fig. 7. — Cushman and Stainforth, 1945, Spec. Publ. 14, Cushman Lab. Foram. Res., p. 67, pl. 12, fig. 13. — Stainforth, 1948, Journ. Pal., vol. 22, no. 1, p. 119, pl. 25, figs. 26—28. — Bermudez, 1949, Spec. Publ. 25, Cushman Lab. Foram. Res., p. 280, pl. 21, figs. 39, 40.

Globigerina sp. Cushman and Jarvis, 1930, Journ. Pal. vol. 4, no. 4, p. 366, pl. 34, figs. 5 a, b.

Globigerina altispira Cushman and Todd (not Cushman and Jarvis, 1936), 1945, Spec. Publ. 15, Cushman Lab. Foram. Res., p. 66, pl. 11, fig. 11.

Specimens in a few cores are identical with the holotype. It is possible that this species should be referred to *G. conglomerata* Schwager. Only one view of that species is figured and Schwager describes it as having a diameter of 0.6 mm. whereas Pacific specimens attain a diameter of almost 1.00 mm. Since there is, therefore, considerable doubt of this identification it seems safer to use Hedberg's name. Brady (1884, p. 596) notes that specimens sent to him by Schwager resemble »*G. dubia*» Egger and are not well illustrated by Schwager's figure.

The references given in the above synonymy have all been checked with types deposited at the U. S. National Museum. The species is described from the Carapita Formation of Venezuela, of Oligocene age. It is reported from the Upper Oligocene of the Dominican Republic; from the Apero marl in the Oligocene of Trinidad; from Ecuador — ranging from the Lower Oligocene to the Middle Miocene with the chief occurrence in the upper Middle and Upper Oligocene; and from the Buff Bay Formation of the Miocene in Jamaica. Palmer (1941, p. 286) reports a form questionably referable to this species from the Cojimar Formation, Upper Oligocene of Cuba. In the West Indian and South American regions the species appears to be most common in the upper Middle and Upper Oligocene, although its range extends above into the Miocene and below into the Lower Oligocene.

Globigerina sp. 1

(Plate 1, figures 22, 23)

This is a very small form, having a thin, smooth wall. It is of rare occurance.

Globigerina sp. 2

(Plate 1, figures 26, 27)

This form bears some resemblance to *G. hexagona* Natland but is smaller, usually has 6 chambers in the last-formed whorl which increases less rapidly in size as added, and has a finer hexagonal pattern in the wall. It occurs in several cores but not in the surface samples.

Globigerinoides conglobata (H. B. Brady)

(Plate 2, figures 1, 2, 3)

Globigerina conglobata H. B. Brady, 1879, Quart. Journ. Micr. Sci., vol. 19, p. 72; 1884, Rep't. Voy. CHALLENGER, Zool., vol. 9, p. 603, pl. 80, figs. 1—5; pl. 82, fig. 5. — Cushman, 1924, Bull. 104, U. S. Nat. Mus., pt. 5, p. 18, pl. 3, figs. 8—13.

Globigerinoides conglobata (H. B. Brady), Schott, 1935, Wiss. Ergeb. deutsch. Atlantisch. Exped. Forsch. Vermess. »Meteor» 1925—1927, vol. 3, pt. 3, Sect. B, p. 59. — Phleger, 1939, Bull. Geol. Soc. America, vol. 50, pl. 1, fig. 8; 1942, ibid., vol. 53, p. 1088. — Cushman and Henbest, 1940, U. S. Geol. Surv. Prof. Paper 196—A, pt. 2, p. 46, pl. 8, fig. 10. — Cushman, 1941, Amer. Journ. Sci., vol. 239, pl. 2, fig. 2. — Parker, 1948, Bull. Mus. Comp. Zool., vol. 100, no. 2, pl. 7, figs. 8, 9. — Ovey, in Wiseman and Ovey, 1950, Proc. Geol. Assoc., vol. 61, pt. 1, p. 68, pl. 3, figs. 8 a, b. — Phleger, 1951, Mem. 46, Geol. Soc. America, pt. 1, p. 68; Phleger and Parker, ibid., pt. 2, p. 35, pl. 19, fig. 15.

This species is reported from the western Atlantic on the continental shelf and slope off the United States south of Cape Cod with frequencies from 0—5 %; in the Gulf of Mexico with a frequency of 5 %; east of Cuba at 2 %; between Lat. 0° and 20° N off the African coast, ±1 % at the south increasing to greater than 5 % to the north. Brady reports its occurrence from Lat. 40° N to 35° S. This northern limit is not expanded by later authors.

Globigerinoides rubra (d'Orbigny)

(Plate 2, figures 4, 7)

Globigerina rubra d'Orbigny, 1839, in de la Sagra, Hist. Phys. Pol. Nat. Cuba, »Foraminifères», p. 82, pl. 4, figs. 12—14. — H. B. Brady, 1884, Rep't. Voy. CHALLENGER, Zool., vol. 9, p. 602, pl. 79, figs. 11—16. — Cushman, 1924, Bull. 104, U. S. Nat. Mus., pt. 5, p. 15, pl. 3, figs. 4—7.

Globigerinoides rubra (d'Orbigny), Schott, 1935, Wiss. Ergeb. deutsch. Atlantisch. Exped. Forsch. Vermess. »Meteor» 1925—1927, vol. 3, pt. 3, Sect. B., p. 59. — Phleger, 1939, Bull. Geol. Soc. America, vol. 50, pl. 1, fig. 12; ibid., 1942, vol. 53, p. 1087. — Cushman and Henbest, 1940, U. S. Geol. Surv. Prof. Paper 196—A, pt. 2, p. 46, pl. 8, fig. 9. — Cushman, 1941, Amer. Journ. Sci., vol. 239, pl. 2, fig. 3. — Parker, 1948, Bull. Mus. Comp. Zool., vol. 100, no. 2, pl. 7, fig. 4. — Ovey, in Wiseman and Ovey, 1950, Proc. Geol. Assoc., vol. 61, pt. 1, p. 68, pl. 3, figs. 12 a, b. — Phleger, 1951, Mem. 46, Geol. Soc. America, pt. 1, p. 68; Phleger and Parker, 1951, ibid., pt. 2, p. 35, pl. 19, fig. 16.

It is possible that some of the forms reported as *Globigerina helicina* d'Orbigny should be included here. This species varies a good deal in shape, number of chambers, etc., but is uniform as regards the character of the wall.

It is reported southwest of the British Isles with a frequency of 0.1 %; between this point and Newfoundland it is absent or rare in a few samples; on the continental shelf of the northeastern United States south of Cape Cod it occurs with average frequencies of 0—3 % increasing to 5—10 % on the slope, although occasionally it may form as much as 50 % of the planktonic fauna; in the Gulf of Mexico it has frequencies of 30—70 %; east of Cuba 17 %; from Lat. 0°—20° N off the coast of Africa it forms 10 % of the fauna to the north increasing to 19 % at 0°; to the westward it decreases to ± 1 % toward the coast of South America. The highest average frequencies occur in the Gulf of Mexico. It is reported by Brady from 49° N to 36° S in the Atlantic with the greatest abundance in the tropics.

Globigerinoides sacculifera (H. B. Brady)

(Plate 2, figures 5, 6)

Globigerina sacculifera H. B. Brady, 1877, Geol. Mag., vol. 4, p. 535; 1879, Quart. Journ. Micr. Sci., vol. 19, p. 73; 1884 Rep't. Voy. CHALLENGER, Zool., vol. 9, p. 604, pl. 80, figs. 11—17; pl. 82, fig. 4. — Cushman, 1924, Bull. 104, U. S. Nat. Mus., pt. 5, p. 21, pl. 4, figs. 1—6.

Globigerinoides sacculifera (H. B. Brady), Schott 1935, Wiss. Ergeb. deutsch. Atlantisch. Exped. Forsch. Vermess. »Meteor» 1925—1927, vol. 3, pt. 3, Sect. B, p. 59. — Phleger, 1939, Bull. Geol. Soc. America, vol. 50, pl. 1, figs. 16, 17; ibid., 1942, vol. 53, p. 1088. — Cushman, 1941, Amer. Journ. Sci., vol. 239, pl. 3, fig. 1. — Parker, 1948, Bull. Mus. Comp. Zool., vol. 100, no. 2, pl. 7, fig. 7. — Ovey, in Wiseman and Ovey, 1950, Proc. Geol. Assoc., vol. 61, pt. 1, p. 68, pl. 3, fig. 5. — Phleger, 1951, Mem. 46, Geol. Soc. America, pt. 1, p. 68; Phleger and Parker, 1951, ibid., pt. 2, p. 35, pl. 19, figs. 17, 18.

This species occurs on the western Atlantic continental shelf and slope of the northeastern United States south of Cape Cod with frequencies of 0—5 %; occasionally 10 %; in the Gulf of Mexico 5—10 %; east of Cuba 24 %; off the coast of Africa from 0°—20° N with varying frequencies of 24 % to the north decreasing to the south to 10 % and again increasing to 60 % at about Lat. 10° N; at 0° there are frequencies of 20—40 %, to the westward the frequencies decrease to 20 % and then increase to 50 % near the coast of South America. Brady gives the distribution in the Atlantic from 40° N to 35° S.

Globigerinita glutinata (Egger)

(Plate 2, figures 12, 13, 14, 15)

Globigerina glutinata Egger, 1893, Abhandl. k. bay. Akad. Wiss München, Cl II, vol. 18, p. 371, pl. 13, figs. 19—21. — Rhumbler, 1911, Ergeb. Plankton-Exped. Humboldt Stift., vol. 3, p. 148, pl. 29, figs. 14—26; pl. 33, fig. 20; pl. 34, fig. 1.

In identifying this species Rhumbler's interpretation has been followed. Egger's figures are poor and he makes no mention, in the description, of the supplementary chambers. It is possible, however, that Rhumbler had access to Egger's material on which to base his identification. The species has been placed in the genus *Globigerinita* although occasional specimens have a second globigerine aperture. The occurrence of the secondary chambers is a variable feature; in some assemblages they are found in a large percentage of the specimens whereas in others they may be quite subordinate. The species may be easily defined, however from the general characters of the test. It is much smaller than *Globigerinoides rubra*, and has a thinner, more finely spinose wall. It differs from the genotype: *Globigerinita naparimaensis* Bronnimann, in that the wall of the supplementary chambers is much smoother and more finely perforate than the rest of the test.

There are no reports of this species in bottom sediments except Egger's at about 10° N Lat. off the coast of Africa in 677 m. where he reports it as rare. Specimens have been observed in material from the northwestern Gulf of Mexico.

Globigerinella aequilateralis (H. B. Brady)

(Plate 2, figures 9, 10, 11)

Globigerina aequilateralis H. B. Brady, 1879, Quart. Journ. Micr. Sci., vol. 19, p. 71; 1884, Rep't. Voy. CHALLENGER, Zool., vol. 9, p. 605, pl. 80, figs. 18—21. — Cushman, 1924, Bull. 104, U. S. Nat. Mus., pt. 5, p. 25, pl. 4, figs. 7, 8.

Globigerinella aequilateralis (H. B. Brady), Schott, 1935, Wiss. Ergeb. deutsch. Atlantisch. Exped. Forsch. Vermess. »Meteor» 1925—1927, vol. 3, pt. 3, Sect. B, p. 59. —

Phleger, 1939, Bull. Geol. Soc. America, vol. 50, p. 1405, pl. 1, figs. 11, 13; 1942, ibid., vol. 53, p. 1096. — Cushman and Henbest, 1940, U. S. Geol. Surv. Prof. Paper 196-A, pt. 2, pl. 8, fig. 11. — Cushman, 1941, Amer. Journ. Sci., vol. 239, pl. 2, fig. 1. — Parker, 1948, Bull. Mus. Comp. Zool., vol. 100, no. 2, p. 238. — Ovey, in Wiseman and Ovey, 1950, Proc. Geol. Assoc., vol. 61, pt. 1, p. 68, pl. 3, figs. 9 a, b. — Phleger, 1951, Mem. 46, Geol. Soc. America, pt. 1, p. 68; Phleger and Parker, ibid., pt. 2, p. 35, pl. 19, fig. 14.

This species is reported with a frequency of 0.3 % southwest of the British Isles; occasionally rare between this point and Newfoundland; on the continental shelf and slope of the northeastern United States south of Cape Cod, 0—1 %; in the Gulf of Mexico 5 %; east of Cuba 13 %; off the coast of Africa from Lat. 0°—20° N mostly ± 1 % although Ovey reports 7 % near the equator. Brady gives a distribution in the Atlantic from 50° N to 35° S.

Orbulina universa d'Orbigny

(Plate 2, figure 8)

Orbulina universa d'Orbigny, 1839, in de la Sagra, Hist. Phys. Pol. Nat. Cuba, »Foraminifères», p. 3, pl. 1, fig. 1. — Brady, 1884, Rep't. Voy. CHALLENGER, Zool., vol. 9, p. 608, pl. 78; pl. 81, figs. 8—26; pl. 82, figs. 1—3. — Cushman, 1924, Bull. 104, U. S. Nat. Mus., pt. 5, p. 28, pl. 5, figs. 2—9; 1941, Amer. Journ. Sci., vol. 239, pl. 4, fig. 2. — Schott, 1935, Wiss. Ergeb. deutsch. Atlantisch. Exped. Forsch. Vermess. »Meteor» 1925—1927, vol. 3, pt. 3, Sect. B, p. 59. — Phleger, 1939, Bull. Geol. Soc. America, vol. 50, p. 1401; 1942, ibid., vol. 53, p. 1088. — Cushman and Henbest, 1940, U. S. Geol. Surv. Prof. Paper 196-A, pt. 2, pl. 8, fig. 8. — Ovey, in Wiseman and Ovey, 1950, Proc. Geol. Assoc., vol. 61, pt. 1, p. 67, pl. 3, fig. 6. — Phleger, 1951, Mem. 46, Geol. Soc. America, pt. 1, p. 68; Phleger and Parker, 1951, ibid., pt. 2, p. 35.

This species is reported southwest of the British Isles with a frequency of 2 %; westward to Newfoundland it occurs with varying abundance but mostly rarely; on the northeastern United States continental shelf and slope 0—1 %; in the Gulf of Mexico 5 %; east of Cuba 23 %; off the coast of Africa from Lat. 0° to 20° N, mostly ± 1 % although one report near the equator gives a frequency of 7 %. Brady gives a range of the species from Nova Zembla to 50° S Latitude.

Pulleniatina obliquiloculata

(Parker and Jones)

(Plate 2, figures 16, 17, 18)

Pullenia obliquiloculata Parker and Jones, 1865, Phil. Trans., vol. 155, p. 368, pl. 19, figs. 4 a, b. — H. B. Brady, 1884, Rep't. Voy. CHALLENGER, Zool., vol. 9, p. 618, pl. 84, figs. 16—20. — Cushman, 1924, Bull. 104, U. S. Nat. Mus., pt. 5, p. 43, pl. 8, fig. 10.

Pulleniatina obliquiloculata (Parker and Jones), Schott, 1935, Wiss. Ergeb. deutsch. Atlantisch. Exped. Forsch. Vermess. »Meteor» 1925—1927, vol. 3, pt. 3, Sect. B, p. 59. — Cushman, 1941, Amer. Journ. Sci., vol. 239, pl. 4, fig. 3. — Parker, 1948, Bull. Mus. Comp. Zool., vol. 100, no. 2, pl. 7, fig. 13. — Ovey, in Wiseman and Ovey, 1950, Proc. Geol. Assoc., vol. 61, pt. 1, p. 69, pl. 3, fig. 7. — Phleger, 1951, Mem. 46, Geol. Soc. America, pt. 1, p. 68; Phleger and Parker, 1951, ibid., p. 35, pl. 19, figs. 19, 20.

This species is reported on the northeastern continental shelf of the United States south of Cape Cod with frequencies of 0—5 % decreasing eastward on the slope to less than 1 % (Phleger, 1942); in the Gulf of Mexico 10—20 %; east of Cuba 0.2 %; off the coast

of Africa the frequency at 20° N is ± 1 % increasing to ± 10 % at the equator and also to the westward toward the coast of South America. The highest frequencies are found in the Gulf of Mexico with a somewhat lower occurrence near the equator extending northward along the coast of South America.

Sphaeroidinella dehiscens (Parker and Jones)

(Plate 2, figure 19)

Sphaeroidina dehiscens Parker and Jones, 1865, Phil. Trans., vol. 155, p. 369, pl. 19, figs. 5 a-c. — H. B. Brady, 1884, Rep't. Voy. CHALLENGER, Zool., vol. 9, p. 621, pl. 84, figs. 8—11. — Cushman, 1924, Bull. 104, U. S. Nat. Mus., pt. 5, p. 38, pl. 7, figs. 7, 8; pl. 8, figs. 1, 2.

Sphaeroidinella dehiscens (Parker and Jones), Schott, 1935, Wiss. Ergeb. deutsch. Atlantisch. Exped. Forsch. Vermess. »Meteor» 1925—1927, vol. 3, pt. 3, Sect. B, p. 59. — Cushman, 1941, Amer. Journ. Sci., vol. 239, p. 136. — Parker, 1948, Bull. Mus. Comp. Zool., vol. 100, no. 2, p. 239. — Ovey, in Wiseman and Ovey, 1950, Proc. Geol. Assoc., vol. 61, pt. 1, p. 69, pl. 3, fig. 4. — Phleger, 1951, Mem. 46, Geol. Soc. America, pt. 1, p. 68; Phleger and Parker, 1951, ibid., p. 35.

This species occurs rarely on the continental shelf south of Cape Cod; in the Gulf of Mexico; east of Cuba with a frequency of 0.7 %; off Africa from Lat. 0° to 20° N with a frequency of ± 1 %. Brady reports its occurrence in the tropical and subtropical areas of the Atlantic and rare occurrence in the vicinity of the British Isles. Cushman (1924) places its northern limit at Lat. 40° N.

Sphaeroidinella rutschi Cushman and Renz

(Plate 2, figures 20, 21)

Sphaeroidinella rutschi Cushman and Renz, 1941, Contr. Cushman Lab. Foram. Res., vol. 17, pt. 1, p. 25, pl. 4, fig. 5. — Bermudez, 1949, Spec. Publ. 25, Cushman Lab. Foram. Res., p. 283, pl. 21, fig. 60.

The smaller specimens of our species are identical with the holotype, but the range of variation is somewhat different from that shown by the paratypes in that our specimens show a more lobulate form. The identification, however, appears to be a close one. There is some resemblance between this species and *S. seminulina* (Schwager) but the latter has only three chambers in the adult form while *S. rutschi* frequently has 4 according to the description. In our assemblages specimens with 5 chambers are occasionally seen.

There seems to be a possibility, however, that *S. rutschi* and *S. seminulina* may be closely related and may even be synonymous. This point cannot be ascertained without large suites of fossil material which we do not have available. The two species appear to have a somewhat similar range in the West Indian region. *S. rutschi* is reported by Cushman and Renz from Lower through Middle Miocene in Venezuela in the lower and upper Agua Salado Formation. Bermudez reports it from the Upper Oligocene of the Dominican Republic, giving an over-all range of lowermost Miocene through Middle Miocene. The range of *S. seminulina* as reported by various authors from the West Indian region is from the Upper Oligocene through the Upper Miocene.

Candeina nitida d'Orbigny

(Plate 2, figures 22, 23)

Candeina nitida d'Orbigny, 1839, in de la Sagra, Hist. Phys. Pol. Nat. Cuba, »Foraminifères», p. 108, pl. 2, figs. 27, 28. — H. B. Brady, 1884, Rep't. Voy. CHALLENGER, Zool., vol. 9, p. 622, pl. 82, figs. 13—20. — Cushman, 1924, Bull. 104, U. S. Nat. Mus., pt. 5, p. 35, pl. 5, fig. 1. — Schott, 1935, Wiss. Ergeb. deutsch. Atlantisch. Exped. Forsch. Vermess. »Meteor» 1925—1927, vol. 3, pt. 3, Sect. B, p. 59.

Brady reports this species in the North Atlantic as far north as 55° 11′ (one station only). Cushman (1924) says that it is found chiefly in the Caribbean and is not to be found north of Cape Hatteras, at approximately Lat. 35° N. This seems more in accordance with the other published occurrences. Schott records it as absent or rare in the area off the African coast from Lat. 0° to 20° N.

Globorotalia hirsuta (d'Orbigny)

(Plate 4, figures 1, 2, 3, 4, 5, 6, 7)

Rotalina hirsuta d'Orbigny, 1839, in Barker-Webb and Berthelot, Hist. Nat. Îles Canaries, vol. 2, pt. 2, »Foraminifères», p. 131, pl. 1, figs, 37—39.

Pulvinulina canariensis H. B. Brady (not d'Orbigny, 1839), 1884, Rep't. Voy. CHALLENGER, Zool., vol. 9, p. 692, pl. 103, figs. 8—10.

Globorotalia hirsuta (d'Orbigny), Cushman, 1931, Bull. 104, U. S. Nat. Mus., pt. 8, p. 99, pl. 17, figs. 6 a—c. — Phleger, 1939, Bull. Geol. Soc. America, vol. 50, pl. 1, figs. 3, 4; — Cushman and Henbest, 1940, U. S. Geol. Surv. Prof. Paper 196—A, pt. 2, pl. 8, fig. 6. — Parker, 1948, Bull. Mus. Comp. Zool., vol. 100, no. 2, pl. 7, figs. 11, 14. — Ovey, in Wiseman and Ovey, 1950, Proc. Geol. Assoc., vol. 61, p. 67, pl. 2, figs. 6 a—c.

This species has been confused by authors with the species referred by us to *G. punctulata* (d'Orbigny) which is plano-convex in all cases. This is the case with the *G. hirsuta* of Cushman and Bermudez (1949, p. 36, pl. 7, figs. 1—3) which represents a variant of *G. punctulata* with an acute periphery. The form referred by Ovey (Wiseman and Ovey, 1950, p. 60, pl. 2, figs 4 a, b) to *G. canariensis* (d'Orbigny) is probaly a variant form of *G. hirsuta*. He reports it in small quantities from the same localities at which he found that species. In many cases we have found associated with typical *G. hirsuta* a small compact form with a thickened periphery (pl. 4, figs. 6, 7). It usually forms a small percentage of the total occurrence of *G. hirsuta* and has been included with that species in the species counts. This form resembles the holotype of *G. crassula* Cushman and R. E. Stewart which is such a poor specimen that there is some difficulty in distinguishing its characteristics.

It is probable that the two species groups, *G. hirsuta* and *G. punctulata*, may be closely related. They are differentiated by the shape of the test, but the number and shape of the chambers is similar. Both species groups show great variation in the character of the periphery from acute to subacute or even almost rounded in extreme cases. It is inadvisable to further subdivide these forms into subspecies owing to the confusion that already exists. It seems better to refer specimens to one of the two groups, based on the shape of test which can be readily distinguished, and to point out the variant forms which may occur in any given case.

G. hirsuta is reported with frequencies of less than 1 % at Lat. 60° N and southwest of the British Isles. Between this point and Newfoundland it is common to abundant according to Cushman and Henbest; on the northeastern continental shelf and slope of the United States south of Cape Cod it has a frequency of less than 1 %; in the Gulf of Mexico it is rare; east of Cuba 0.1 %; It was originally described from the Canary Islands and is probably the form referred by Schott to *G. canariensis* (1935, p. 105) which he reports as occurring rarely off the coast of Africa from Lat. 0° to 20° N.

Globorotalia menardii (d'Orbigny)

(Plate 3, figures 1, 2, 4, 5)

Rotalia menardii d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 273, no. 26; Modèles no. 10.

Pulvinulina menardii (d'Orbigny), H. B. Brady, 1884, Rep't. Voy. CHALLENGER, Zool., vol. 9, p. 690, pl. 103, figs. 1, 2.

Globorotalia menardii (d'Orbigny), Cushman, 1931, Bull. 104, U. S. Nat. Mus., pt. 8, p. 91, pl. 17, figs. 1 a—c; 1941, Amer. Journ. Sci., vol. 239, pl. 3, fig. 2. — Schott, 1935, Wiss. Ergeb. deutsch. Atlantisch. Exped. Forsch. Vermess. »Meteor» 1925—1927, vol. 3, pt. 3, Sect. B, p. 60. — Phleger, 1939, Bull. Geol. Soc. America, vol. 50, pl. 1, figs. 1, 2; 1942, ibid., vol. 53, p. 1093. — Cushman and Henbest, 1940, U. S. Geol. Surv. Prof. Paper 196—A, pt. 2, p. 46, pl. 8, fig. 3. — Parker, 1948, Bull. Mus. Comp. Zool., vol. 100, no. 2, pl. 7, fig. 10. — Ovey, in Wiseman and Ovey, 1950, Proc. Geol. Assoc. vol. 61, pt. 1, p. 69, pl. 3, figs. 1 a—c. — Phleger, 1951, Mem. 46, Geol. Soc. America, pt. 1, p. 68; Phleger and Parker, 1951, ibid., pt. 2, p. 36, pl. 20, figs. 1, 2.

This species is easily separable from the typical form of *G. tumida* (H. B. Brady) in surface samples and the upper part of most cores as it is a much less tumid form with a more rounded outline. Farther down in the cores specimens occur which combine characteristics of the two species. These are listed in the tables as »*menardii-tumida* group». Various forms included in this group are figured in Plate 3, figures 4—11. Occurring with them are frequently found typical specimens of *G. menardii*. Additional remarks on these forms will be found under *G. tumida*.

G. menardii is reported as rare to common (6—25 specimens) in the surface samples of two cores west of Newfoundland in the vicinity of Long. 40° W; on the continental shelf and slope of the northeastern United States south of Cape Cod from 0—5 % in most cases; in the Gulf of Mexico 5—10 %; east of Cuba 7 %; off the coast of Africa from Lat. 0° to 20° N±20 %. Brady gives a distribution in the Atlantic from 55° 11′ N to 51° 36′ S.

Globorotalia multicamerata
Cushman and Jarvis
(Plate 3, figures 9, 12)

Globorotalia menardi (d'Orbigny) var. *multicamerata* Cushman and Jarvis, 1930, Journ. Pal., vol. 4, no. 4, p. 367, pl. 34, fig. 8.

This species is described from the Miocene of Buff Bay, Jamaica. The only report from the Recent is by Cushman and Bermudez (1949, p. 30) from 810 fms., north of Cuba. The known range of the species is from the Middle Miocene to the Recent, with all but one of the reported occurrences from the Miocene of Jamaica and Cuba.

Globorotalia punctulata (d'Orbigny)
(Plate 4, figures 8, 9, 10, 11, 12)

Globigerina punctulata d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 277, no. 8. — Fornasini, 1898, Paleont. Ital., vol. 4, p. 210, text. fig. 5.

Pulvinulina crassa H. B. Brady (not *Rotalina crassa* d'Orbigny, 1840), 1884, Rep't. Voy. CHALLENGER, Zool., vol. 9, p. 694, pl. 103, figs. 11, 12.

Globigerina inflata Cushman (not d'Orbigny, 1839), 1941, Amer. Journ. Sci., vol. 239, pl. 1, fig. 12.

Globorotalia (*Turborotalia*) *oceanica* Cushman and Bermudez, 1949, Contr. Cushman Lab. Foram. Res., vol. 25, pt. 2, p. 43, pl. 8, figs. 13—15.

Globorotalia hirsuta Cushman and Bermudez (not d'Orbigny, 1839), ibid., p. 36, pl. 7, figs. 1—3.

Globorotalia crassula Ovey, in Wiseman and Ovey (not Cushman and Stewart, 1930), 1950, Proc. Geol. Assoc., vol. 61, pt. 1, p. 66, pl. 2, figs. 8 a—c.

Globorotalia punctulata (d'Orbigny), Phleger, 1951, Mem. 46, Geol. Soc. America, pt. 1, p. 68; Phleger and Parker, 1951, ibid., pt. 2, p. 36, pl. 20, figs. 3—7.

The above synonymy includes some variant forms which appear to us to belong to the

species group *G. punctulata*. It is of interest to note that four species have been erected by authors who place Brady's »*Pulvinulina crassa*» from the CHALLENGER Report in the synonymy. These are:

1) *Globigerina crassaformis* Galloway and Wissler (Brady's pl. 103, figs. 11, 12). The type of this species has not been seen but it appears to be synonymous to our *G. punctulata*.
2) *Globorotalia crassula* Cushman and. R. E. Stewart (Brady's pl. 103, figs. 11, 12). The holotype is a very poor specimen which appears to be referable to the *G. hirsuta* group.
3) *Globorotalia pseudocrassa* Chapman and Parr (Brady's pl. 103, fig. 12 (not. fig. 11)). Ovey places this species in the synonymy under his »*G. crassula*» which in turn we have assigned to *G. punctulata*. He based this on specimens sent by Parr.
4) *Globorotalia oceanica* Cushman and Bermudez (Brady's pl. 103, figs. 11, 12). The holotype is referable to *G. punctulata* and the species placed in the above synonymy.

The reasons for referring this species to *G. punctulata* (d'Orbigny) have been given in a previous publication (Phleger and Parker, 1951). This opinion has been strengthened by the study of further material from Rimini which contains specimens definitely referable to d'Orbigny's species as exemplified by his figures published by Fornasini. These specimens are identical with those found in the North Atlantic.

This species, as was pointed out under *G. hirsuta*, shows variations in the character of the periphery from acute to subacute and the reasons for not further subdividing it are the same as those given there. An example is the Cuban form »*G. hirsuta*» of Cushman and Bermudez, given in the above synonymy, which represents a variant with a very sharp periphery which has been also observed in the Gulf of Mexico and is apparently not commonly found in the North Atlantic. Except for the acuteness of the periphery it is identical with the species as figured by Fornasini, Brady, and others, and does not seem to us to be specifically different.

G. punctulata is reported with a frequency of 0.4 % southwest of the British Isles; less than 5 % in the Gulf of Mexico; 0.1 % east of Cuba. The species referred to *G. crassa* by Schott (1935, p. 60), probably referable to *G. punctulata*, is found off the coast of Africa from Lat. 0° to 20° N with frequencies of ± 1 %. This is confirmed by the findings of Ovey at a station near the equator.

Brady reports the northern range of the species at Lat. 54° 53′ N.

Globorotalia scitula (H. B. Brady)

(Plate 4, figures 13, 14)

Pulvinulina scitula H. B. Brady, 1882, Proc. Roy. Soc. Edinburgh, vol. 11, p. 716. — Balkwill and Millett, 1884, Journ. Micr., vol. 3, p. 85, pl. 4, fig. 12.

Pulvinulina patagonica H. B. Brady (not d'Orbigny, 1839), 1884, Rep't. Voy. CHALLENGER, Zool., vol. 9, p. 693, pl. 103, fig. 7.

Globorotalia scitula (H. B. Brady), Cushman, 1931, Bull. 104, U. S. Nat. Mus., pt. 8, p. 100, pl. 17, figs. 5 a—c. — Cushman and Henbest, 1940, U. S. Geol. Surv. Prof. Paper 196—A, pt. 2, pl. 8, fig. 5. — Ovey, in Wiseman and Ovey, 1950, Proc. Geol. Assoc., vol. 61, pt. 1, p. 69, pl. 3, figs. 11 a—c. — Phleger, 1951, Mem. 46, Geol. Soc. America, pt. 1, p. 68; Phleger and Parker, 1951, ibid., pt. 2, p. 36, pl. 20, figs. 8, 9.

This species is reported with a frequency of 0.2 % southwest of the British Isles; as rare up to occurences of 6—26 specimens between this point and Newfoundland; at one station on the continental slope of the United States

at close to Lat. 40° N; in the Gulf of Mexico less than 5 %; east of Cuba 0.2 %.

Brady gives a general distribution in the Atlantic from 60° N to 46° S.

Globorotalia truncatulinoides (d'Orbigny)

(Plate 4, figures 17, 18)

Rotalina truncatulinoides d'Orbigny, 1839, in Barker-Webb and Berthelot, Hist. Nat. Îles Canaries, vol. 2, pt. 2, »Foraminifères», p. 132, pl. 2, figs. 25—27.

Pulvinulina michelineana H. B. Brady (not d'Orbigny, 1840), 1884, Rep't. Voy. CHALLENGER, Zool., vol. 9, p. 694, pl. 104, figs. 1, 2.

Globorotalia truncatulinoides (d'Orbigny), Cushman, 1931, Bull. 104, U. S. Nat. Mus., pt. 8, p. 97, pl. 17, figs. 4 a—c; 1941, Amer. Journ. Sci., vol. 239, pl. 4, fig. 1. — Schott, 1935, Wiss. Ergeb. deutsch. Atlantisch. Exped. Forsch. Vermess. »Meteor» 1925—1927, vol. 3, pt. 3, Sect. B, p. 60. — Phleger, 1939, Bull. Geol. Soc. America, vol. 50, pl. 1, figs. 9, 10; — Parker, 1948, Bull. Mus. Comp. Zool., vol. 100, no. 2, pl. 7, figs. 12, 15. — Ovey, in Wiseman and Ovey, 1950, Proc. Geol. Assoc., vol. 61, pt. 1, p. 66, pl. 2, figs. 7 a—c. — Phleger, 1951, Mem. 46, Geol. Soc. America, pt. 1, p. 68; Phleger and Parker, 1951, ibid., pt. 2, p. 36, pl. 20, figs. 10—13.

This species is reported at 60° N Lat. with a frequency of 0.7 %; southwest of the British Isles 2 %; between this point and Newfoundland common to abundant; on the northeastern continental shelf and slope of the United States south of Cape Cod 0—1 %; in the Gulf of Mexico 10—20 %; east of Cuba 3 %; off Africa between Lat. 0° and 20° N ± 1 %. The highest frequencies have been reported from the Gulf of Mexico.

Brady gives the general distribution in the Atlantic from the Arctic 79° 26′ N to 46° 46′ S.

Globorotalia tumida (H. B. Brady)

(Plate 3, figures 3, 6, 7, 8, 10, 11)

Pulvinulina menardii d'Orbigny var. *tumida* H. B. Brady, 1877, Geol. Mag., vol. 4, p. 294.

Pulvinulina tumida H. B. Brady, 1884, Rep't. Voy. CHALLENGER, Zool., vol. 9, p. 692, pl. 103, figs. 4—6.

Globorotalia tumida (H. B. Brady), Cushman, 1931, Bull. 104, U. S. Nat. Mus., pt. 8, p. 95, pl. 17, figs. 3 a—c. — Schott, 1935, Wiss Ergeb. deutsch. Atlantisch. Exped. Forsch. Vermess. »Meteor» 1925—1927, vol. 3, pt. 3, Sect. B, p. 60. — Cushman, 1941, Amer. Journ. Sci., vol. 239, pl. 3, fig. 3. — Phleger, 1939, Bull. Geol. Soc. America, vol. 50, pl. 1, figs. 5—7; 1942, ibid., vol. 53. — Parker, 1948, Bull. Mus. Comp. Zool., vol. 100, no. 2, pl. 7, figs. 16, 17. —Ovey, in Wiseman and Ovey, 1950, Proc. Geol. Assoc., vol. 61, pt. 1, p. 69, pl. 3, figs. 11 a—c. — Phleger, 1951, Mem. 46, Geol. Soc. America, pt. 1, p. 68; Phleger and Parker, 1951, ibid., pt. 2, p. 36, pl. 20, figs. 14, 15.

For the relationship between this species and *G. menardii* see the remarks under that species. Typical *G. tumida* as figured by Brady and as seen in present day samples occurs only in the upper sections of our cores and has been presumably only recently (geologically speaking) evolved from the so-called *menardii-tumida* complex occuring lower down in the cores. One interesting variant is that shown in pl. 3, figures 10, 11, in which the last-formed chamber is narrow and sharply bent toward the ventral side. This is listed on the charts in the *menardii-tumida* group since it is hard to be certain to which species it belongs, although it perhaps shows a closer affinity to *G. tumida*.

G. tumida is reported on the continental shelf and slope of the northeastern United States south of Cape Cod with frequencies of

0—1 %; in the Gulf of Mexico 5 %; east of Cuba 1 %; off the coast of Africa it has a frequency of about 10 % at 20° N increasing to the southwest to greater than 40 %, then decreasing at Lat. 10° N to ± 1 %, and increasing to about 40 % near Fernando Noronka; to the east on the equator decreasing rapidly to ± 1 % and then increasing to ±20 % near the African coast.

Brady gives the distribution in the Atlantic from 38° 34′ N to 35° 39′ S.

Globorotalia sp. 1

(Plate 4, figures 19, 20, 21)

This species is plano-convex, with a smooth, polished wall. The ventral side is very convex and has a closed umbilicus. There are 3—4 chambers in the last-formed whorl.

The species is found in one sample near the bottom of one core.

Globorotalia sp. 2

(Plate 4, figures 15, 16)

This species resembles *G. menardii* in some respects but has a plano-convex test having 6—7 chambers in the last-formed whorl. It occurs in cores containing fossil forms of known age, but appears higher than those species in the cores.

Specimens of this form have been observed in Middle Miocene Bowden Marl material from Jamaica.

Benthonic Species

The benthonic species form a very small percentage of the total faunas in both the surface samples and the cores. In most cases it was necessary to count all the benthonic specimens in a sample in an attempt to get an adequate number for statistical analysis. Often, however, this procedure did not yield a sufficient quantity. For this reason the distributions of the various forms cannot be given with accuracy, except perhaps in the case of the more common and persistent ones. Absence of any species in a core, or at least in various parts of a core, does not mean that the species was non-existent at that particular time, or in that particular area. Much can be deduced, however, by noting occurrences in various cores in an area although almost nothing can be from the intermittent occurrences within a core. A notable exception to this is the occurrence of displaced faunas. Here analyses can be made on the basis of the occurrence or absence of whole groups of species based on an analysis of several cores containing representatives of these groups in varying amounts. These occurrences will be discussed in more detail later.

The scarcity of benthonic specimens also leads to another difficulty, that of taxonomic analysis. Many specimens occur in too small numbers to give an adequate picture of the range of variation of the species. It was often necessary to study suites composed of single specimens picked from various samples.

In spite of the scarcity of the benthonic forms one fact can be deduced with considerable accuracy. This is that most deep-water benthonic forms have a wide range of occurrence, being found throughout the area. Many of these same species are also found in the deep waters of the Pacific and appear to be almost universally present in deep water where Foraminifera are found. Whether or not this is due to the essentially uniform temperature of the deep layers is an interesting problem.

There is a considerable number of arenaceous species found in the surface samples, more rarely in the »top» samples of the long cores. These species are found very rarely in the cores below the »top». They have not been listed separately in Table 38, giving species occurrence in the surface samples, because of the doubtful value of such information. They

are listed as a group, however, since in aggregate they often form a relatively high percentage of the benthonic fauna. Since these species are not included in the species discussions a brief discussion follows. The species having the most widespread occurrence in the area is *Adercotryma glomeratum* (H. B. Brady), occurring in 23 of the 53 surface samples. Other species of interest are: *Cystammina galatea* (H. B. Brady), found in 10 samples; *C. pauciloculata* (H. B. Brady), in 7 samples; *Proteonina difflugiformis* (H. B. Brady) in 11 samples. Various specimens of *Recurvoides*, *Cyclammina*, *Reophax* and *Trochammina* occur in small quantities in many samples but not in a sufficient number for safe identification. In addition there are very rare occurrences of several additional species. It is interesting to speculate on the reasons for the usual absence of these species in the cores, below the top. One explanation is that the cementing material is weakened by solution; another that many of the species are very fragile and easily broken and may not be able to withstand compaction.

A study of displaced faunas in several cores has resulted in the formation of a list of what are believed to be reliable key species indicative of displacement from comparatively shallow depths. A second list of species contains forms that are questionably related to the displaced faunas, since they have occasionally been found in other cores where displacement cannot be established, but where, nevertheless, it may be present. The method of establishing the presence and especially the extent of these faunas may be of interest since all the species involved have not come from very shallow depths. The faunas containing such known shallow-water species as *Amphistegina lessonii*, *Rotalia beccarii* variants and various species of *Elphidium* were first analyzed and the associated species noted. The occurrences of these allied species were then studied and where they were noted in discrete assemblages the faunas were again analyzed. By this process it was possible to weed out the known deep-water forms leaving a residue of forms that were probably present due to transportation. These species, then, are only found in association with each other and not apparently disseminated indiscriminately through the cores. In the case of a few of the species a few exceptions in occurrence are noted where there is not enough evidence for displacement by the presence of a sufficient number of these species. This does not rule out the possibility of there being displacement in those particular cases, however. Further discussion of the whole problem and the actual occurrence in the various cores is given elsewhere.

The following species appear to be displaced forms. Their previously reported depth occurrences are given, many of which are taken from Brady's report on the CHALLENGER Expedition and may include displaced occurrences. Where possible more precise information is given from various sources.

Anomalina balthica Schroeter: less than 3,000 m.

Amphistegina lessonii d'Orbigny: 0—90 m. (in most cases)

Angulogerina selseyensis (Heron-Allen and Earland): shallow water off Cuba; Selsey, England, shore sand

Bolivina globulosa Cushman: (1 exception); less than 5270 m. in tropical Pacific

B. paula Cushman and Cahill: Miocene (shallow facies?)

B. pseudoplicata Heron-Allen and Earland: less than 90 m. except in Skagerak where it is most common at 200 m.

B. pulchella (d'Orbigny): less than 1,500 m.

B. subaenariensis Cushman: (1 exception); 155—2,981 m. (H. B. Brady); less than 1,000 m. (Phleger)

B. tortuosa H. B. Brady: mostly shallow water

B. sp. 1

Bulimina exilis H. B. Brady: 1,829—2,743 m. (H. B. Brady)

B. marginata d'Orbigny var.: less than 2,981 m. (H. B. Brady)

B. mexicana Cushman: 80—2,430 m.

B. aff. *subacuminata* Cushman and R. E. Stewart: deeper than 670 m. in Pacific off California

Cancris cf. *oblonga* (Williamson): less than 200 m.

Cassidulina curvata Phleger and Parker: deeper than 90 m. (Gulf of Mexico)

C. norcrossi australis Phleger and Parker: 200—700 m. (Gulf of Mexico)

C. sp. 1

Cassidulinoides mexicana (Cushman): 40 m. off Florida; 1,488 m. in Caribbean

Cibicides cf. *refulgens* Montfort: 82—4,390 m.

Cibicidina rhodiensis (Terquem): 30—512 m. (Red Sea)

Cornuspira planorbis Schultze: no definite data

Discorbis bertheloti (d'Orbigny): 0—650 m.

D. cf. *columbiensis* Cushman: shallow

D. mamilla (Williamson): shallow

D. obtusa (d'Orbigny): no conclusive data

Elphidium advenum (Cushman): shallow

E. complanatum (d'Orbigny): 100—200 m. (off coast of Africa)

E. crispum (Linné): less than 726 m.; usually less than 300 m.

Nonion asterizans (Fichtel and Moll): 9—322 m.; usually less than 100 m.

Nonionella sloanii (d'Orbigny): described from shore sands of Cuba; little additional data

N. sp.

Planorbulina mediterranensis d'Orbigny: less than 1,160 m.; usually less than 150 m.

Pullenia cf. *riveroi* Bermudez: less than 1,042 m. based on rather sparse data

Rectuvigerina sp.

»*Rotalia*» *beccarii* (Linné) variants: shallow

»*R.*» *translucens* Phleger and Parker: 25—1,000 (Gulf of Mexico)

Tretomphalus atlanticus Cushman: shallow (West Indies)

Uvigerina senticosa Cushman: less than 500 m. off California

U. sp. 1

U. sp. 2

Valvulineria araucana (d'Orbigny): 80—160 m. in most cases

Virgulina mexicana Cushman: 110—1,350 m. (Gulf of Mexico)

V. tessellata Phleger and Parker: less than 1,000 m. (Gulf of Mexico)

The following species are questionably displaced forms. They have been found in a few cases associated with assemblages that cannot necessarily be considered as displaced.

Bolivina cf. *minuta* Natland: deeper than 274 m. off California

Bulimina aculeata d'Orbigny: 100—2,800 m. in most cases

Cibicides lobatulus (Walker and Jacob): widespread reports

Discorbis williamsoni Parr: 0—1,860 m.; mostly less than 100 m.

Nonionella atlantica Cushman: less than 200 m. (Gulf of Mexico); usually less than 70 m.

Nummoloculina irregularis (d'Orbigny): deeper than 640 m.

Ophthalmidium inconstans H. B. Brady: widespread reports

Rotamorphina laevigata (Phleger and Parker): deeper than 300 m.

Trochammina cf. *advena* Cushman: less than 1,850 m.; usually less than 60 m.

Benthonic species of possible Miocene age occur in Cores 233 and 238. They are in both cases associated with planktonic species also of probable Miocene age. The benthonic species are: *Buliminella* sp., *Cassidulina reflexa* Galloway and Wissler and *Bolivina* sp. 2. Further discussion of these species is given in the section on the interpretation of the core faunas and in the species discussions.

For convenience in presenting the taxonomic material, Cushman's classification is used; in many cases the types have been seen at the

U. S. National Museum in Washington, D. C., and in many other cases topotype material has been studied. Distributions in the North Atlantic as reported in the literature are given together with the distributions observed in this study.

Family AMMODISCIDAE

Glomospira charoides (Jones and Parker)

(Plate 5, figure 1)

Trochammina squamata var. *charoides* Jones and Parker, 1 860, Quart. Journ. Geol. Soc., vol. 16, p. 304.

Trochammina charoides Jones and Parker, Carpenter, Parker and Jones, 1 862, Introd. Foram., p. 141, pl. 11, fig. 3.

This species is reported from depths greater than 200 m. It occurs rarely in Cores 228, 234, and 246.

Glomospira cf. gordialis (Jones and Parker)

(Plate 5, figure 2)

Trochammina squamata var. *gordialis* Jones and Parker, 1 860, Quart. Journ. Geol. Soc., vol. 16, p. 304.

Trochammina gordialis Jones and Parker, Carpenter, Parker and Jones, 1,862, Introd. Foram. p. 141, pl. 11, fig. 4.

A few specimens occur having a smooth, polished test. In other respects they are similar to Jones and Parker's species, which is widely distributed, with most reported occurrences from deep water. It occurs in Cores 217, 242, 246, and 267, and from surface samples 225, 235, 267, 281, 283, and REHOBETH Sta. 3—29 and 3—41.

Family TEXTULARIIDAE

Textularia australis Parr

(Plate 5, figures 3, 4)

Textularia australis Parr, 1950, B. A. N. Z. Antarctic Res. Exped. 1929—1931, Ser. B, vol. 5, pt. 6, p. 275, pl. 4, figs. 30 a—c.

North Atlantic specimens resemble Parr's except for their smaller size, the maximum length being 0.9 mm., the average length 0.7 mm. The species is not reported from the Atlantic. It occurs widely in the cores and in surface samples 236, 252, 257, 258, and ATLANTIS Sta. 4,637, 4,736, and 4,739.

Siphotextularia curta (Cushman)

(Plate 5, figures 5, 6)

Textularia flintii var. *curta* Cushman, 1922, Bull. 104, U. S. Nat. Mus., pt. 3, p. 14, pl. 2, figs. 2, 3.

North Atlantic specimens are identical with the types. Cushman reports the species from the Caribbean, deeper than 406 m. It is probable that it is also reported under other names but this cannot be confirmed. The species occurs in Cores 221, 267, 288, 290, and in surface sample ATLANTIS Sta. 4,631.

Siphotextularia rolshauseni Phleger and Parker

(Plate 5, figure 7)

Siphotextularia rolshauseni Phleger and Parker, 1951, Mem. 46, Geol. Soc. America, pt. 2, p. 4, pl. 1, figs. 23, 24 a, b.

Textularia catenata Cusman 1922 (not Cushman, 1911), Bull. 104, U. S. Nat. Mus., pt. 3, p. 12, pl. 6, fig. 3.

North Atlantic specimens are larger than those from the Gulf of Mexico with an average length of 0.5 mm. They are also slightly more compressed. Cushman's plesiotype of *S. catenata* from the Atlantic is identical but the North Atlantic species does not resemble the holotype of that species described from the Pacific, which, from the description, is a much larger form. It is possible that the Atlantic forms represent a subspecies of *S. rolshauseni* but the two forms are undoubtedly very closely related. The species is widely distributed in the cores and surface samples.

Family VALVULINIDAE

Eggerella bradyi (Cushman)

(Plate 5, figures 8, 9)

Verneuilina bradyi Cushman, 1911, Bull 71, U. S. Nat. Mus., pt. 2, p. 54, text figs. 87 a, b.

Verneuilina pygmaea H. B. Brady (not *Bulimina pygmaea* Egger, 1857), 1884, Rep't. Voy. CHALLENGER, Zool., vol. 9, p. 385, pl. 47, figs. 4—7.

Adult specimens of this species may have a very short biserial stage. For this reason it might be more accurate to designate the species a *Karreriella*. Inasmuch, however, as the great majority of specimens do not reach this stage it seems more expedient to keep the species in the genus *Eggerella*. This expediency is further emphasized by the fact that there is already a species *Karreriella bradyi* (Cushman) which is referred to extensively in the literature of both fossil and Recent material. As »*Verneuilina bradyi*» has priority over »*Gaudryina bradyi*», the original name of *Karreriella bradyi*, a different interpretation of *K. bradyi* would cause great confusion. Specimens of this species from PORCUPINE Sta. 36, close to Brady's locality of the figured CHALLENGER specimens of his »*Gaudryina pupoides* d'Orbigny» which Cushman renamed, show a small form with a long biserial series of slightly overlapping chambers. Similar forms occur in the Gulf of Mexico, the West Indies and elsewhere, but are not found except for questionable very rare occurrences in the North Atlantic material. *Eggerella bradyi*, which is very common in the North Atlantic, is usually larger although there is great variation in size. The specimens showing the very short biserial stage are often the same size as *K. bradyi*. Young forms of the two species are probably very difficult to differentiate and for this reason many reports of *Eggerella bradyi* may be referable to *Karreriella bradyi*.

This applies especially to the very small specimens in the *Eggerella* stage of development which are frequently seen without adult specimens. It seems probable that most of these forms in the North Atlantic material are referable to *E. bradyi* since so few *Karreriella bradyi* adult specimens are seen. The depth range of *K. bradyi* appears to be less extensive and it is probably limited to depths of 155—1,326 m., although Brady reports it deeper. *Eggerella bradyi* is reported deeper than 600 m. The species shows a range of variation in the character of the wall from smooth, polished to slightly roughened but there is in all cases a large quantity of calcareous cement. The species is widely distributed in the cores and surface samples.

Plectina apicularis (Cushman)

(Plate 5, figure 10)

Gaudryina apicularis Cushman, 1911, Bull. 71, U. S. Nat. Mus., pt. 2, p. 69, text figs. 110 a, b.

This species is reported from the North Atlantic usually deeper than 700 m. and from the Gulf of Mexico deeper than 200 m. It is widely distributed in the surface samples and also occurs at the top, or near the top, in about ten scattered cores. The deepest occurrence in the cores is at 210 cm. in Core 217.

Family MILIOLIDAE

Quinqueloculina venusta Karrer

(Plate 5, figures 11, 12)

Quinqueloculina venusta Karrer, 1868, Sitz. k. Akad. Wiss. Wien., vol. 58, Abth. 1, p. 147, pl. 2, fig. 6.

This species is reported deeper than 3292 m. It is widespread in the cores and surface samples.

Quinqueloculina cf. **weaveri** Rau

(Plate 5, figures 13, 14)

Quinqueloculina weaveri Rau, 1948, Journ. Pal., vol. 22, no. 2, p. 159, pl. 28, figs 1—3.

This species is very similar to Rau's except that the periphery is slightly less rounded and the chambers are slightly angled. The character of the aperture is very similar and in both forms there is no tooth, an unusual feature. Most of the North Atlantic specimens are smaller than Rau's species, described from the Porter shale of Washingron, probably upper Eocene in age. It is widely distributed in the North Atlantic in both cores and surface samples.

Spiroloculina sp.

(Plate 5, figures 15, 16)

This species resembles *Spirolocammina tenuis* Heron-Allen and Earland but has a calcareous test which is entirely destroyed by acid, except for a thin, chitinous inner layer. Rare occurrences are found in scattered cores throughout the area, except in the cores along the South American coast, and in surface samples 285, 289, 292, and ATLANTIS Sta. 4635 and 4637.

Sigmoilina schlumbergeri A. Silvestri

(Plate 5, figure 17)

Sigmoilina schlumbergeri A. Silvestri, 1904, Mem. Pont. Accad. Nuovi Lincei, vol. 22, p. 267.

This species is reported deeper than 80 m. It is found in cores south of Lat. 25° N along the African coast, in Core 267 and in the group from 289—296. It also occurs in surface samples in these same areas.

Sigmoilina tenuis (Czjzek)

(Plate 5, figure 18)

Quinqueloculina tenuis Czjzek, 1848, Haidinger's Nat. Abhandl., vol. 2, p. 149, pl. 13, figs. 31—34.

North Atlantic specimens are slightly more compressed, with slightly narrower chambers than those from the Miocene at Baden in the Vienna Basin. They are otherwise very similar. The species is reported from the Bay of Naples deeper than 200 m. It is found in many cores from 215—252 along the Coast of Africa and in the southern part of the area, and in the northern group of cores 279—296. It occurs in only two surface samples, at ATLANTIS Sta. 4637 and 4736.

Nummoloculina irregularis (d'Orbigny)

(Plate 5, figures 19, 20)

Biloculina irregularis d'Orbigny, 1839, Voy. Amér. Mérid., vol. 5, pt. 5, »Foraminifères», p. 67, pl. 8, figs. 20, 21.

Brady (1884, p. 140) reports this species from a few stations in the mid-latitudes deeper than 640 m. It occurs associated with displaced faunas in Cores 215, 221, 252, 258, 267, and in a questionably displaced fauna in Core 246. It is found in surface samples 267 and ATLANTIS Sta. 4631.

Triloculina tricarinata d'Orbigny

(Plate 5, figure 21)

Triloculina tricarinata d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 299, no 7; Modèles no. 94.

This species has a very wide distribution according to the reports in the literature. It is found in scattered cores from Cores 242—258, in Core 267 and in many of the northern group 284—296. It occurs in three surface samples: 267, REHOBETH Sta. 3—32 and SAN PABLO Sta. 3—47.

Pyrgo murrhina (Schwager)

(Plate 5, figures 22, 23, 24)

Biloculina murrhina Schwager, 1866, Novara Exped., Geol. Theil., vol. 2, p. 203, pl. 4, figs. 15 a—c.

This species varies a great deal in size and shape. The characteristic sinus at the

lower end of the test, with its two projecting points, is often lacking in adult specimens. Many report of *P. depressa* (d'Orbigny) include specimens of this type. The aperture of d'Orbigny's species is very different, however, being a very elongate, narrow slit near the apex of the test. The aperture of *P. murrhina* varies in breadth, being much less broad in juvenile specimens. It is reported deeper than 200 m. in the North Atlantic but has its highest frequency between 100—200 m. in the northwestern Gulf of Mexico. It is widely distributed in the cores and surface samples.

Pyrgo oblonga (d'Orbigny)

(Plate 5, figures 25, 26)

Biloculina oblonga d'Orbigny, 1839, in de la Sagra, Hist. Phys. Pol. Nat. Cuba, »Foraminifères», p. 163, pl. 8, figs. 21—23.

The prolongation of the neck and the angle of the periphery vary in this species. The periphery may be rounded to carinate, suites of specimens showing a transition from the two extremes. d'Orbigny's figure illustrates the form with rounded periphery. In most cases the apertural neck is longer than that shown in his figure, but specimens identical to his occur. Some of the reports of *P. elongata* (d'Orbigny) may be referable to *P. oblonga*, which is widely distributed in the cores and occurs in surface samples ATLANTIS Sta. 4736, and REHOBETH Sta. 3—29.

Family OPHTHALMIDIIDAE

Cornuspira planorbis Schultze

(Plate 5, figure 30)

Cornuspira planorbis Schultze, 1854, Organismus Polythal., p. 40, pl. 2, fig. 21.

This species is rare. It occurs in Cores 228, 248, 252, and 267.

Ophthalmidium inconstans (H. B. Brady)

(Plate 5, figure 27)

Ophthalmidium inconstans H. B. Brady, 1884, Rep't. Voy. CHALLENGER, Zool., vol. 9, p. 189, pl. 12, figs. 5, 7, 8. (*Haverina inconstans* Brady, 1879).

This species is widely reported in the North Atlantic. It occurs in Cores 248, 267, 289, and in surface sample ATLANTIS Sta. 4631.

Spirophthalmidium acutimargo (H. B. Brady)

(Plate 5, figures 28, 29)

Spiroloculina acutimargo H. B. Brady, 1884, Rep't. Voy. CHALLENGER, Zool., vol. 9, p. 154, pl. 10, fig. 13 (not figs. 12, 14, 15).

The reported distribution in the North Atlantic is confused by the inclusion of more than one species. *S. acutimargo* is reported off the coast of Ireland in 170 m. It occurs in Cores 228, 236, 267 and 288.

Family TROCHAMMINIDAE

Trochammina cf. advena Cushman

(Plate 6, figures 1, 2)

Trochammina advena Cushman, 1922, Publ. 311, Carnegie Instit. Washington, p. 20, pl. 1, figs. 2—4.

A few specimens occur in Core 267, most of which resemble the holotype. One specimen is much larger, reaching a diameter of 0.54 mm. The species is reported from the Tortugas region, off Florida, from 9—19 m. In the Gulf of Mexico it is most frequent shallower than 60 m. but occurs to a depth of 1850 m.

Family NONIONIDAE

Nonion asterizans (Fichtel and Moll)

(Plate 6, figure 3)

Nautilus asterizans Fichtel and Moll, 1798, Text. Micr., p. 37, pl. 3, figs. e—h.

North Atlantic specimens are identical with topotypes from Rimini, Italy, and are also very

much like topotypes of *N. boueanum* (d'Orbigny) from the Miocene of Nussdorf in the Vienna Basin. From the few specimens examined the two species appear to be synonymous but a study of larger suites may show statistical differences. This has also been pointed out by Marks (1951, p. 48). The form reported by Colom (1950, p. 26) off the coast of Bojador, Africa, as *N. boueanum* is undoubtedly our species. He reports it as common to frequent from 9—100 m. and infrequent to a depth of 322 m. A few specimens occur in Core 221, associated at least in part with a displaced faunal assemblage.

Nonion barleeanum (Williamson)

(Plate 6, figure 4)

Nonionina barleeana Williamson, 1858, Rec. Foram. Great Britain, p. 32, pl. 3, figs. 68, 69.

This species is allied to *N. pompilioides* (Fichtel and Moll) and *N. formosum* (Seguenza). It is more compressed than most specimens of *N. pompilioides* and has more limbate sutures which fuse into a very much thickened ring of clear shell material at the umbilicus. The last-formed whorl seldom has less than 10 chambers and often more. *N. formosum* has narrow sutures, fewer chambers, and non-limbate sutures without the central ring of fused material. The three species are variable but can be easily separated once the main characteristics are understood. There has been too much confusion within this group to give the reported distribution accurately. This species is widely distributed in the cores and occurs in widely scattered surface samples.

Nonion formosum (Seguenza)

(Plate 6, figure 5)

Nonionina formosa Seguenza, 1880, Atti R. Accad. Lincei, ser. 3, vol. 6, p. 63, pl. 7, figs. 6, 6 a.

North Atlantic specimens are identical with topotypes from the Tertiary of Calabria, Italy. See *N. barleeanum* for a comparison with that species. *N. formosum* is more compressed than *N. pompilioides*, more finely perforate, and usually has a closed umbilicus. The form recorded by Cushman and Henbest (1940, pl. 9, fig. 13) as *N. barleeanum* should be referred to this species, which has not been recorded as such from the Recent. It is widely distributed in the cores and surface samples.

Nonion germanicum (Ehrenberg)

(Plate 6, figure 6)

Nonionina germanica Ehrenberg, 1839, Abhandl. k. Akad. Wiss. Berlin, p. 133, pl. 2, figs. 1 a—g.

Ehrenberg records this species from the North Sea. Williamson (1858, p. 33, pl. 3, figs. 70, 71) records it as *N. crassula* (Walker and Jacob) in the vicinity of the British Isles. It is widely distributed in the cores and occurs in scattered surface samples mostly in the southern part of the area with the exception of REHOBETH Sta. 3—29.

Nonion pompilioides (Fichtel and Moll)

(Plate 6, figures 7, 8)

Nautilus pompilioides Fichtel and Moll, 1798, Test. Micr., p. 31, pl. 2, figs. a—c.

This species rarely has more than 9 chambers in the last whorl. It is more coarsely perforate than *N. barleeanum* and more deeply umbilicate without the greatly thickened ring around the umbilicus. Some of the large, less-compressed specimens of *N. barleeanum* are difficult to separate from this form and it is necessary to have a good sequence of specimens for study. Both species apparently occur in the Mediterranean and it is probable that many forms referred to *N. pompilioides* should be referred to *N. barleeanum*. The characteristics of Fichtel and Moll's species are well illustrated by specimens from the Pliocene of Coroncina, Italy,

where they reported its occurrence. It is interesting to note that associated with this species at that locality there is a species closely related to *N. barleeanum*. The two species are apparently frequently associated as is found to be the case in the North Atlantic where *N. pompilioides* is widely distributed in both cores and surface samples.

Nonionella atlantica Cushman

(Plate 6, figures 9, 10)

Nonionella atlantica Cushman, 1947, Contr. Cushman Lab. Foram. Res., vol. 23, pt. 4, p. 90, pl. 20, figs. 4, 5.

This species is reported off Florida and in the northwestern Gulf of Mexico at depths shallower than 200 m., with the highest frequency shallower than 70 m. It is associated with displaced faunal assemblages in Cores 257, 258, and 262, and with questionably displaced faunas in Cores 233 and 242.

Nonionella sloanii (d'Orbigny)

(Plate 6, figures 11, 12)

Nonionina sloanii d'Orbigny, 1839, in de la Sagra, Hist. Phys. Pol. Nat. Cuba, »Foraminifères», p. 46, pl. 6, figs. 18, 18 bis.

d'Orbigny describes this species from shore sands of Cuba. Our specimens are identical with Cuban specimens and are referable to the genus *Nonionella*. The species is associated with displaced faunal assemblages in Cores 248, 252, 257, and 267.

Nonionella sp.

(Plate 6, figures 13, 14)

This is a smaller, less compressed, less turgid form than *N. opima* Cushman. It has 8 slightly inflated chambers and a small lobe. It occurs in Core 252 associated with a displaced faunal assemblage. It is assumed to be a shallow water species since species of this type do not appear to be indigenous to deep water environments.

Elphidium advenum (Cushman)

(Plate 6, figure 15)

Polystomella advena Cushman, 1922, Publ. 311, Carnegie Instit. Washington, p. 56, pl. 9, figs. 11, 12.

This species is reported only from shallow water. It is associated with displaced faunal assemblages in Cores 221, 228, 252 and 267.

Elphidium complanatum (d'Orbigny)

(Plate 6, figure 16)

Polystomella complanata d'Orbigny, in Barker-Webb and Berthelot, Hist. Nat. Îles Canaries, vol. 2, pt. 2, »Foraminifères», p. 129, pl. 2 figs. 35, 36.

This species is very similar to d'Orbigny's figured specimens except that it has a slight keel. He describes the species as having a diameter of 0.33 mm. The largest of our specimens has a diameter of 0.68 mm. A specimen identical with ours has been found in material from CHALLENGER Sta. 8 off Gomera in the Canary Islands. Colom (1950, p. 27, pl. 9, figs. 10, 11) has similar specimens which he refers also to *E. complanatum*. His species, too, has a keeled periphery. Colom's material came from close to the Canaries off the coast of Africa at Bojador. Under the circumstances it seems safe to assume that d'Orbigny overlooked the slight keel since his figure agrees closely in other repects. Colom reports the species in his 100—200 m. facies. The specimens he figures on his plate 3 b are apparently referable not to this species but to *E. crispum*.

Elphidium crispum (Linné)

(Plate 6, figure 17)

Nautilus crispus Linné, 1758, Syst. Nat. ed. 10, p. 709.

A study of specimens from Rimini, Italy, shows that there is probably no specific difference between *E. crispum* and *E. macellum*

(Fichtel and Moll). All gradations may be seen between the two forms. Most of the specimens found in the cores are of the *E. macellum* type, with a small umbo and about 20 chambers or less in the last-formed whorl. This may be due to the fact that all the specimens are relatively small. Colom (1950, p. 27) reports *E. crispum* in abundance off the coast of Bojador, Africa, out to a depth of 300 m., with occasional occurrences to a depth of 726 m. It occurs associated with displaced faunal assemblages in Cores 215 and 221 off the coast of Africa.

Family BULIMINIDAE

Buliminella sp.

(Plate 6, figure 18)

A few specimens occur in Core 233 at 801 cm. and below. The species has not been described but specimens have been observed in Oligo-Miocene material from Haiti collected by W. P. Woodring. The specimens are very short and broad and are decorated with irregular costae. Fine radiating grooves extend from the aperture which is in a sunken area near the apex of the test.

Robertina bradyi Cushman and Parker

(Plate 6, figures 19, 20)

Robertina bradyi Cushman and Parker, 1936, Contr. Cushman Lab. Foram. Res., vol. 12, pt. 4, p. 99, pl. 16, figs. 9 a, b.

This species was described from the Caribbean at a depth of 698 m. It occurs in Cores 221, 223, 246, 267 and 288. The reasons for retaining this species in the genus *Robertina* are given by Parker (1952, p. 416).

Bulimina aculeata d'Orbigny

(Plate 6, figures 21, 22)

Bulimina aculeata d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 269, no. 7.

Polymorphia pineiformis Soldani (part), 1791, Test., vol. 1, pt. 2, p. 118, pl. 127, fig. 1?; pl. 130, fig. *vv*.

Most records in the North Atlantic are from depths between 100 m. and 2800 m. The species is associated with displaced faunas in many of the southern group of cores listed as containing these faunas. It also occurs in Cores 280, 288, 289, 290 and 292 in the northern group and in surface samples 224, and SAN PABLO Sta. 3—47. Whether or not its presence indicates displacement in all cases is open to question.

Bulimina alazanensis Cushman

(Plate 6, figure 23)

Bulimina alazanensis Cushman, 1927, Journ. Pal., vol. 1, p. 161, pl. 25, fig. 4.

This species is reported in the Gulf of Mexico from 400—1800 m. No data is given on depths in the North Atlantic but it is reported from the West Indies and near Ireland. It has a widespread occurrence in the cores and surface samples.

Bulimina exilis H. B. Brady

(Plate 6, figure 24)

Bulimina elegans d'Orbigny var. *exilis* H. B. Brady, 1884, Rep't. Voy. CHALLENGER, Zool., vol. 9, p. 399, pl. 50, figs. 5, 6.

Brady reports this species in the North Atlantic from 1829—2743 m. Parker (1948, p. 225) reports it at shallower depths on the western continental slope with a minimum depth of 359 m. This corroborates Cushman's findings in the same general area (1922, p. 106). Heron-Allen and Earland (1916, p. 234) report it from very shallow depths west of Scotland. It is associated with displaced faunal assemblages in Cores 221, 252, 257, 258 and 262 and occurs in the top sample of Core 280, which questionably contains displaced forms.

Bulimina marginata d'Orbigny variant

(Plate 6, figures 25, 26)

Bulimina marginata d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 269, no. 4, pl. 12, figs. 10—12.

Occasional specimens are found which are smaller and usually less spinose than the Rimini specimens figured by d'Orbigny. *B. marginata* is recorded from a wide range of depths. Brady (1884, p. 405) reports its deepest occurrence at 2981 m. and it is also frequently reported in very shallow water. If a sufficient number of specimens could be obtained from deep water for statistical analysis they might show specific differences from the shallow water form. The variant found by Parker (1948, p. 225) in the deeper part of the continental shelf and adjacent slope of the western Atlantic is unlike the present variant in being very spinose. This form is associated with displaced faunal assemblages in Cores 221, 228, 252, 257, 258 and 262.

Bulimina mexicana Cushman

(Plate 6, figure 27)

Bulimina inflata Seguenza var. *mexicana* Cushman, 1922, Bull. 104, U. S. Nat. Mus., pt. 3, p. 95, pl. 21, fig. 2.

This species is reported from mid latitudes in the North Atlantic from 80—2,430 m. It is associated with displaced faunal assemblages in Cores 215, 221, 252 and 267. It also occurs in Core 290.

Bulimina aff. **subacuminata** Cushman and R. E. Stewart

(Plate 6, figures 28, 29)

Bulimina subacuminata Cushman and R. E. Stewart, 1930, in Cushman, Stewart and Stewart, San Diego Nat. Hist. Trans., vol. 6, no. 2, p. 65, pl. 5, figs. 2, 3 a, b.

North Atlantic specimens are very similar to Cushman and Stewart's species but the costae are slightly finer and do not extend so far up onto the chambers. The species is not reported from the Atlantic but is found deeper than 670 m. off the coast of California. It is associated with a displaced faunal assemblage in Core 221.

Bulimina translucens Parker, n. sp.

(Plate 6, figures 30, 31)

Test small, slender, gradually tapering from the widest point at the midpoint of the last-formed whorl, megalospheric form about twice as long as broad, microspheric three times, initial end rounded, the microspheric form with six or seven whorls, the megalospheric about five; chambers distinct, slightly inflated, increasing gradually in size as added; sutures distinct, slightly depressed; wall smooth, tinely perforate, translucent, the lower part of fhe test often, not always, decorated by a few low, curving costae which extend as much as halfway up the test, aperture moderately broad, loopshaped, above the junction of the second and third chambers, near the apex of the test. Maximum length 0.44 mm.; maximum width 0.2 mm.

The holotype is from ATLANTIS Sta. 4637, Lat. 35° 22′ N, Long. 10° 23′ W, at a depth of 4,181 m.

The dimensions given above are for large specimens but many are much smaller with a length of about 0.3 mm. The larger specimens are almost invariably decorated with the costae; the proportion of the smaller ones so decorated is less. Frequently the costae are so low and translucent that it is difficult to detect them. This species most closely resembles *B. thanetensis* Cushman and Parker but is much more finely perforate and is usually costate on the lower part of the test. The chambers are less inflated than in *B. elongata* d'Orbigny. The species occurs in Cores 242, 246, 248, 252, 257, 258, 284, and in surface samples 284 and ATLANTIS Sta. 4637.

Globobulimina affinis (d'Orbigny)

(Plate 6, figure 32)

Bulimina affinis d'Orbigny, 1839, in de la Sagra, Hist. Phys. Pol. Nat. Cuba, »Foraminifères», p. 105, pl. 2, figs 25, 26.

This species is reclassified as a *Globobulimina* in accordance with Höglund's (1947, p. 237) revision of the generic description. The structure of the aperture and tongue accords with his definition, as well as the less densely perforate wall. The species is reported from the Atlantic from deeper than 97 m. It occurs in Cores 258 and 288.

Globobulimina (Desinobulimina) cf. **turgida** (Bailey)

(Plate 6, figures 33, 34)

Bulimina turgida Bailey, 1851, Smithsonian Contr., vol. 2, p. 12, pl., figs. 28—31.

The North Atlantic specimens are similar to Bailey's except that they are not always spinose. Höglund (1947, p. 248) found that his specimens of this species did not have a terminal aperture without a suture, but specimens from the Atlantic continental shelf have this feature although not as frequently as do specimens of *G.* (*D.*) *auriculata* (Bailey). *G.* (*D.*) *turgida* is reported from the western Atlantic continental shelf deeper than 90 m. and from the Skagerak as abundant from 200—300 m., being rare at deeper or shallower stations. The species occurs in Cores 221, 223, 233 and surface samples 224 and 225.

Virgulina advena Cushman

(Plate 7, figures 1, 2)

Virgulina (?) *advena* Cushman, 1922, Bull. 104, U. S. Nat. Mus., pt. 3, p. 120, pl. 25, figs. 1—3.

Cushman questioned the genus of this form when he described it. Although the narrow aperture extending over the apex of the test is an unusual feature of the genus, the internal structure of the aperture is very similar to that of other species of the genus. The only apparent dissimilarity is that the tongue extending inward from the border of the aperture is only slightly curving and does not bend back toward the free apertural border. The species is reported deeper than 236 m. It is widespread in the cores except along the coast of South America north of Lat. 34° N in the western part of the area. It is found in surface samples 285 and SAN PABLO Sta. 3—47.

Virgulina bradyi Cushman

(Plate 7, figures 4, 5)

Virgulina bradyi Cushman, 1922, Bull. 104, U. S. Nat. Mus., pt. 3, p. 115, pl. 24, fig. 1.

This species is reported in the North Atlantic deeper than 258 m. It is widely distributed in the cores and occurs in surface samples 224, 225, 230, 234 and REHOBETH Sta. 3—38.

Virgulina complanata Egger

(Plate 7, figure 3)

Virgulina schreibersiana Czjzek var. *complanata* Egger, 1893, Abhandl. k. bay Akad. Wiss. München, Cl. II, vol. 18, p. 292, pl. 8, figs. 91, 92.

In the Gulf of Mexico this species is most abundant at depths of less than 1,000 m. It is also found on the western Atlantic continental shelf and slope. It is widely distributed in the cores and occurs in surface samples 224, 258 and ATLANTIS Sta. 4,637.

Virgulina mexicana Cushman

(Plate 7, figures 6, 7)

Virgulina mexicana Cushman, 1922, Bull. 104, U. S. Nat. Mus., pt. 3, p. 120, pl. 23, fig. 8.

This species is reported from the Gulf of Mexico deeper than 90 m. Brady (1884, p.

415, pl. 52, figs. 10, 11 (not 7, 8, 9)) reports it as *V. subsquammosa* (part) in the North Atlantic, but its distribution cannot be separated from that of the other species that he includes under that name. *V. mexicana* is associated with displaced faunal assemblages in Cores 221, 248, and 252.

Virgulina tessellata Phleger and Parker

(Plate 7, figure 8)

Virgulina tessellata Phleger and Parker, 1951, Mem. 46, Geol. Soc. America, pt. 2, p. 19, pl. 9, figs. 15 a, b, 16 a, b.

This species is reported as rare in the northwestern Gulf of Mexico shallower than 1,000 m. It is associated with displaced faunal assemblages in Cores 248 and 252.

Virgulina sp.

(Plate 7, figures 9, 10)

This is a small, translucent species which somewhat resembles *V. tessellata* in having the lower part of the chambers perforate. It is more rapidly tapering than that species and does not have contrasting opaque and translucent areas on the chambers. It occurs in Cores 246, 248 and 284.

Bolivina globulosa Cushman

(Plate 7, figure 11)

Bolivina globulosa Cushman, 1933, Contr. Cushman Lab. Foram. Res., vol. 9, pt. 4, p. 80, pl. 8, figs. 9 a, b.

North Atlantic specimens are identical with the holotype. The species is reported from deep water in the tropical Pacific but not from the Atlantic. It is associated with shallow-water displaced faunal assemblages in Cores 242, 248, 252 and 267 off St. Croix and in the equatorial region.

Bolivina cf. minuta Natland

(Plate 7, figure 12)

Bolivina minuta Natland, 1938, Bull. Scripps Instit. Ocean., Techn. Ser., vol. 4, no. 5, p. 146, pl. 5, fig. 10.

Bolivina sp. (?) Cushman and Henbest, 1940, Prof. Paper 196—A, U. S. Geol. Surv., pt. 2, pl. 9, fig. 24.

Most of the specimens are thicker, with more highly raised sutures than Natland's species, but include in their range of variation specimens very close to his. The species appears also to be related to *Loxostomum abruptum* Phleger and Parker but never develops a terminal aperture. It particularly resembles the forms mentioned from the Gulf of Mexico, which were thicker and more twisted with more highly raised sutures (Phleger and Parker, 1951, p. 17, referred to *L. truncatum* Phleger and Parker (not Finlay, 1947)). It is possible that the study of larger suites of specimens from off the coast of California might show that Natland's species develops a terminal aperture also. This would probably necessitate the suppression of *L. abruptum* as a synonym. *B. minuta* is reported off the coast of California deeper than 274 m. It is found at low frequencies in Cores 248 and 252 associated with displaced faunal assemblages, and in Cores 233, 238, and surface samples 267, ATLANTIS Sta. 4,631, 4,633, and REHOBETH Sta. 3—38. The distribution is, therefore, in two distinct groups, one near the equator and the other between Latitudes 31° N and 37° N.

Bolivina paula Cushman and Cahill

(Plate 7, figures 13, 14)

Bolivina paula Cushman and Cahill, 1932, in Cushman and Ponton, Bull. 9, Florida Geol. Surv., p. 84, pl. 12, figs. 6 a, b.

This species is described from the Miocene, Yorktown Formation, in Virginia and is reported from various Miocene localities of the eastern

United States. It is not reported from the Recent. The species is associated with displaced faunal assemblages in Cores 248, 252, and 267 off the equator and near St. Croix. It is probably of Recent origin and not present as a reworked fossil since no other reworked fossil forms have been found associated with the faunas with the possible exception of Core 267.

Bolivina petterssoni Parker, n. sp.

(Plate 7, figures 15, 16, 17)

Test large, very gradually tapering, 2—3 times as long as broad, the widest part of the test being close to the apertural end, initial end rounded, periphery subacute at the initial end, rounded at the apertural end, the chambers of the early portion often overhanging, occasionally throughout most of the test in megalospheric forms; chambers inflated, with a maximum of 11 pairs, increasing gradually in height as added; sutures depressed, curving, at an angle of about 45° with the horizontal; wall translucent, with medium sized perforations uniformly scattered over the whole surface of the chambers; aperture broadly elliptical, slightly curved. Maximum length 0.83 mm.; width 0.33 mm.

Holotype from Core 221, ≠ 56, 549.5—550 cm. from the top, Lat. 22° 31′ N, Long. 23° 28′ W, at a depth of 4940 m.

This species differs from *B. malovensis* Heron-Allen and Earland in its larger size, more inflated chambers which overhang at the periphery at least in the early portion of the test, and broader aperture. It is found only in Core 221 where it occurs at frequencies varying from 1—50 % throughout most of the core.

Bolivina pseudoplicata Heron-Allen and Earland

(Plate 7, figures 18, 19)

Bolivina pseudoplicata Heron-Allen and Earland, 1930, Journ. Roy. Micr. Soc., vol. 50, p. 81, pl. 3, figs. 36—40.

In this species the character of the periphery varies greatly from rounded to sharply acute, or even slightly keeled. Some of the specimens closely resemble those from Plymouth Sound. This species is reported as a shallow water form by most authors, from less than 90 m. depth. Höglund, however, found that it was most abundant at 200 m. in the Skagerak. It is associated with displaced faunal assemblages in Cores 221, 228, 248, 252 and 267. It also occurs in Core 217 where there is slight evidence of displacement of material. All occurrences are south of Lat. 23° N.

Bolivina pseudopunctata Höglund

(Plate 7, figures 20, 21)

Bolivina pseudopunctata Höglund, 1947, Zool. Bidrag från Uppsala, bd. 26, p. 273, pl. 24, fig. 5; pl. 32, figs. 23, 24; text. figs. 280, 281, 287.

Höglund reports this species as most common in the deeper parts of the Gullmar Fjord and the Skagerak. It has been observed off Greenland from 31—457 m. and at a few localities in the Gulf of Maine. It is widely distributed in the cores, but only occurs in one surface sample, SAN PABLO Sta. 3—47.

Bolivina pulchella (d'Orbigny)

(Plate 7, figure 22)

Sagrina pulchella d'Orbigny, 1839, in de la Sagra, Hist. Phys. Pol. Nat. Cuba, »Foraminifères», p. 150, pl. 1, figs. 23, 24.

This species is reported in the West Indian region, ranging from Rio de Janeiro to Bermuda, from shallow depths to 1500 m. It is found in Cores 248, 252 and 267 associated with displaced faunal assemblages.

Bolivina pusilla Schwager

(Plate 7, figure 23)

Bolivina pusilla Schwager, 1866, Novara-Exped. Geol. Theil., vol. 2, p. 254, pl. 7, fig. 101.

This species is reported from the Pacific between 154 m. and 2743 m. Specimens were compared with Pacific specimens in the Cushman collection at the U. S. National Museum and appear to be identical. It occurs in Core 290, near the bottom of the core, starting at 529.5 cm.

Bolivina subaenariensis Cushman

(Plate 7, figures 24, 25)

Bolivina subaenariensis Cushman, 1922, Bull. 104, U. S. Nat. Mus., pt. 3, p. 46, pl. 7, fig. 6.

This species is reported from the western North Atlantic, usually from depths greater than 114 m. Cushman (1937, p. 156) calls very similar specimens from the eastern Atlantic a variant form. Brady (1884, p. 423) reports this form as *B. aenariensis* (Costa) at depths greater than 155 m. Colom (1950, p. 22) reports *B. subaenariensis* off the coast of Africa at 312 m. The deepest reported occurrences are those of Brady at 2981 m. and Phleger (1942, p. 1081) at 1000 m. on the western Atlantic continental slope. The species is associated with displaced faunal assemblages in Cores 221, 248, 252, 258 and 262. It also occurs in the top sample of Core 280 and surface sample 228.

Bolivina tortuosa H. B. Brady

(Plate 7, figure 26)

Bolivina tortuosa H. B. Brady, 1881, Quart. Journ. Micr. Soc., vol. 21, p. 57; 1884, Rep't. Voy. CHALLENGER, Zool., vol. 9, p. 420, pl. 52, figs. 31, 32 (not figs. 33, 34).

Most of the recorded occurrences of this species are from shallow water. Cushman (1937, p. 134) records it from the West Indian region from Brazil to Bermuda. Our occurrences, although probably displaced, fit this general pattern except for one occurrence in a core off the coast of Africa where Cushman's variety *atlantica* has been previously reported. The species is associated with displaced faunas in Cores 215, 248 and 252.

Bolivina sp. 1

(Plate 7, figures 27, 28)

This species resembles *B. spathulata* (Williamson) but is less compressed, and has a less lobulate keel. The specimen figured on plate 27, figure 28, represents a broad form which may be the megalospheric form. There are too few specimens to study the species in detail and establish its identity. It is associated with a displaced faunal assemblage in Core 221.

Bolivina sp. 2

(Plate 7, figure 29)

This species has apparently not been described. It is associated with fossil forms of possible Miocene age in Core 233. Only a few specimens were observed.

Uvigerina auberiana d'Orbigny and variants

(Plate 7, figures 30, 31, 32, 33, 34, 35)

Uvigerina auberiana d'Orbigny, 1839, in de la Sagra, Hist. Phys. Pol. Nat. Cuba, »Foraminifères», p. 106, pl. 2, figs. 23, 24.

d'Orbigny figures a very small form, 0.33 mm. in length. Specimens of this size (Plate 7, figures 30—32) occur in Cores 288, 290 and in material from CHALLENGER Sta. 24 in the West Indies. In Core 267 south of St. Croix are specimens (plate 7, figures 34, 35) which are very much larger (1.5 mm. in length) but otherwise identical. Specimens of this type according to Cushman (1923, p. 163, pl. 42, figs. 3, 4) represent the typical form developed in the West Indies but this does not seem to be necessarily the case. Variant forms in both size groups are referable to *U. ampullacea* (Schwager) and appear to be well within the range of variation of *U.*

auberiana. For this reason it is probable that *U. ampullacea* should be placed in the synonymy under d'Orbigny's species. Many types of variation are seen in both size groups in shape of test and ratio of width to length. Often associated with the northern form in the cores are specimens (plate 7, figure 33) with slightly jutting chambers which are frequently spinose at the chamber margins. These specimens cannot be easily separated from the main group. The species occurs in Cores 215, 267, 288, 290 and at the surface at ATLANTIS Sta. 4631.

Uvigerina hollicki Thalmann and variants

(Plate 8, figures 1, 2, 3)

Uvigerina peregrina Cushman var. *bradyana* Cushman, 1923 (not *U. bradyana* Fornasini), Bull. 104, U. S. Nat. Mus., pt. 4, p. 168, pl. 42, fig. 12.

Uvigerina hollicki Thalmann, 1950, Contr. Cushman Found. Foram. Res., vol. 1, pts. 3—4, p. 45.

Like most *Uvigerina* species *U. hollicki* is very variable. The variations are very much like those of the *U. peregrina* group but the costae are lower and the test often much larger in size. Variations occur in the degree to which the test is spinose. One variant form (plate 8, fig. 3) is very spinose and has more inflated chambers than usual. This form sometimes occurs with the more typical form and again may alternate with it at various depths in a core. It is listed as *U. hollicki* var. in the occurrence tables when it occurs alone, but is not differentiated when it occurs with the more typical form. Another variant form has a short, broad test (plate 8, figure 2). In Core 246 all specimens are of this type but they are difficult to differentiate when mixed with normal specimens. *U. hollicki* appears to replace in deep water *U. peregrina* which is found on the western continental slope. The species reported by Parker (1948) as *U. peregrina* var. *bradyana* is not referable to *U. hollicki*. *U. hollicki* is widespread in the cores and surface samples throughout the area.

Uvigerina senticosa Cushman

(Plate 8, figures 4, 5)

Uvigerina senticosa Cushman, 1927, Bull. Scripps Instit. Ocean., Techn. Ser., vol. 1, no. 10, p. 159, pl. 3, fig. 14.

This species is not reported from the Atlantic but occurs off the coast of California at depths of less than 500 m. It is found in Core 221 associated with a displaced faunal assemblage.

Uvigerina sp. 1

(Plate 8, figure 6)

This is a small costate form associated with displaced faunal assemblages in Cores 257 and 262.

Uvigerina sp. 2

(Plate 8, figure 7)

This is a small, smooth form showing occasional traces of costae. It is associated with a displaced faunal assemblage in Core 257.

Rectuvigerina sp.

(Plate 8, figure 8)

This species occurs only in Core 228 and has apparently never been described. It is somewhat compressed and has only one or two uniserial chambers. It is decorated with fine costae which are broken at the sutures. Mathews' (1945, p. 590) description of the genus *Rectuvigerina* does not include compressed forms but this species seems to conform to the description in every other way.

Angulogerina selseyensis
(Heron-Allen and Earland)

(Plate 8, figure 9)

Uvigerina selseyensis Heron-Allen and Earland, 1909, Journ. Roy. Micr. Soc., p. 437, pl. 18, figs. 1—3.

Core specimens are identical with Cuban specimens so identified by Bermudez (1935, p. 198). A topotype from Selsey, England, shore sands has a more elongate test but is similar in most respects. Additional specimens are needed to show the range of variation of the species and may reveal a specific difference between the western Atlantic and British forms. The species is reported as fossil from the Selsey shore sands and as Recent from shallow water off the north coast of Cuba. It is found in displaced faunal assemblages in Cores 248, 252, and 267 off St. Croix and the coast of Brazil.

Family ELLIPSOIDINIDAE

Pleurostomella acuminata Cushman

(Plate 8, figures 10, 11, 12, 13)

Pleurostomella acuminata Cushman, 1922, Bull. 104, U. S. Nat. Mus., pt. 3, p. 50, pl. 19, fig. 6.

This species is reported from the Caribbean in deep water. It occurs in Cores 234, 242 and 267.

Family ROTALIIDAE

Patellina corrugata Williamson

(Plate 8, figure 14)

Patellina corrugata Williamson, 1858, Rec. Foram. Great Britain, p. 46, pl. 3, figs. 86—89.

This species is reported at all depths. It occurs in Cores 221, 223, 228, 246, 252, 267 and 292, but is not found in any of the surface samples.

Discorbis bertheloti (d'Orbigny)

(Plate 8, figures 15 a, b)

Rosalina bertheloti d'Orbigny, 1839, in Barker-Webb and Berthelot, Hist. Nat. Îles Canaries, vol. 2, pt. 2, »Foraminifères», p. 135, pl. 1, figs. 28—30.

Hofker (1951, p. 359) has proposed the new genus *Discopulvinulina* with this species as the genotype. It appears, however, that this species is similar in its apertural characteristics to »*Rosalina globularis*» d'Orbigny, the genotype of the genus *Rosalina*. For this reason, if this species and other similar ones should be separated from the genus *Discorbis*, as seems probable, the generic name *Rosalina* should be used. We have not made this change here as it does not seem advisable until the situation is more thoroughly understood. *D. bertheloti* is reported from depths of 0—65 m. It is rare in Core 257 where it is associated with a displaced faunal assemblage.

Discorbis cf. columbiensis Cushman

(Plate 8, figures 16, 17)

Discorbis columbiensis Cushman, 1925, Contr. Cushman Lab. Foram. Res., vol. 1, pt. 2, p. 43, pl. 6, figs. 13 a—c.

Very small specimens are found, not exceeding 0.25 mm. in diameter. The species is reported only from nearshore, shallow water. It occurs associated with displaced faunal assemblages in Cores 248, 252, and 267.

Discorbis mamilla (Williamson)

(Plate 8, figures 18, 23, 24)

Rotalina mamilla Williamson, 1858, Rec. Foram. Great Britain, p. 54, pl. 4, figs. 109—111.

This species is placed in the genus *Discorbis* somewhat doubtfully. It has some characteristics in common with *Pninaella nitidula* (Chaster). The chief one is the presence of

secondary plates covering the apertures of chambers previous to the final one, giving a star-shaped effect to the ventral side of the test. This characteristic was not described, however, by Brotzen (1948, p. 119) in his description of the genus *Pninaella*. The main feature of this genus is lacking in *D. mamilla:* the large size of the aperture such that the aperture occupies a large area of the septal wall as described by Brotzen and present in *Pninaella nitidula*. The aperture, however, is larger than in most species of *Discorbis*. This species has been frequently referred to *D. rosacea* (d'Orbigny). It is variable in height of spire, concavity of the ventral side, and acuteness of the periphery. Many of these variations are shown by Heron-Allen and Earland (1913, pl. 11, figs. 4—12) and referred by them to several species. *D. mamilla* is reported only from shallow water. It is associated with displaced faunal assemblages in Cores 215, 221 and 228.

Discorbis obtusa (d'Orbigny)

(Plate 8, figures 25, 26, 27, 28)

Rosalina obtusa d'Orbigny, 1846, Foram. Foss. Bass. Tert. Vienne, p. 179, pl. 11, figs. 4 a—c.

Although this species is reported from the North Atlantic there is little data on its depth distribution. It is associated with displaced faunal assemblages in Cores 215 and 252.

Discorbis williamsoni Parr

(Plate 8, figures 19, 20, 21, 22)

Discorbis williamsoni Parr, 1932, Proc. Roy. Soc. Victoria, vol. 44 (n. s.), pt. 2, p. 226, pl. 21, fig. 25.

Rotalina nitida Williamson (not. *R. nitida* Reuss, 1844), 1858, Rec. Foram. Great Britain, p. 54, pl. 4, figs. 106—108.

Included with this species are specimens (plate 8, figures 21, 22) referable to *D. parkerae* Natland (1950, p. 27). There is some doubt of the validity of this species as in most cases *D. williamsoni* is sufficiently variable to include low spired specimens with four or five chambers such as those that Natland describes. Specimens from the vicinity of the British Isles show such variations. Separation of the two forms could only be verified by statistical analysis and the species is not sufficiently common in the cores to carry out such an analysis. *D. williamsoni* is reported from 0—186 m. although most reports are from less than 100 m. *D. parkerae* is reported by Natland from less than 25 m. in the Gulf of California. The species is reported associated with displaced faunal assemblages in Cores 215, 221, 228, 248, 252 and 267. It also occurs in surface samples 246, ATLANTIS Sta. 4631, and SAN PABLO Sta. 3—47. A variant form questionably referred to this species occurs in Core 290.

Valvulineria araucana (d'Orbigny)

(Plate 8, figures 29, 30)

Rosalina araucana d'Orbigny, 1839, Voy. Amér. Mérid., vol. 5, pt. 5, »Foraminifères», p. 44, pl. 6, figs. 16—18.

This species is reported in the Gulf of Mexico, chiefly between the depths of 80 m. and 160 m. It is associated with a displaced fauna in Core 252.

Valvulineria humilis (H. B. Brady)

(Plate 8, figures 31, 32)

Truncatulina humilis H. B. Brady, 1884, Rep't. Voy. CHALLENGER, Zool., vol. 9, p. 665, pl. 94, figs. 7 a—c.

This species is reported deeper than 1830 m. in the Atlantic. It is so small that most specimens have probably occurred in the uncounted fine fractions. It is found in scattered cores throughout the area.

Gyroidina lamarckiana (d'Orbigny)

(Plate 8, figures 33, 34)

Rotalina lamarckiana d'Orbigny, 1839, in Barker-Webb and Berthelot, Hist. Nat. Îles Canaries, vol. 2, pt. 2, »Foraminifères», p. 131, pl. 2, figs. 13—15.

This is a more compressed form than most species of *Gyroidina* but otherwise conforms most nearly to that genus. It resembles d'Orbigny's figures very closely in size and in other respects except for the character of the aperture which is not so extensive. It is a rather short opening about half-way between the umbilicus and the periphery, in some cases nearly reaching the periphery, with a definite lip. There are usually seven, occasionally eight, chambers in the last-formed whorl. The wall is thin, finely perforate, and slightly translucent. The only report is d'Orbigny's from the Canary Islands. It has a widespread occurrence in the cores and is found in surface samples 230, 232, 234, 257, 258, 261 and ATLANTIS Sta. 4637.

Gyroidina orbicularis d'Orbigny

(Plate 8, figures 35, 36)

Gyroidina orbicularis d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 278, no. 1; Modèles no. 13.

North Atlantic specimens are smaller than those from Rimini, Italy, but otherwise identical. The species is reported from deeper than 300 m. It is widespread in cores and surface samples.

Gyroidina soldanii d'Orbigny variants

(Plate 9, figures 1, 2)

Gyroidina soldanii d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 278, no. 5; Modèles no. 36.

North Atlantic specimens are apparently related to d'Orbigny's species but have fewer chambers, more slanting sutures than Rimini, Italy, specimens and usually a closed umbilicus. Frequently associated with them is a small species which is very difficult to separate from young specimens and which has been included with the counts of *G. soldanii*. Most records in the North Atlantic are from deeper than 500 m. although Parker (1948) records it from deeper than 90 m. on the western Atlantic continental shelf. It is widespread in the cores and surface samples.

Eponides polius Phleger and Parker

(Plate 9, figures 3, 4)

Eponides polius Phleger and Parker, 1951, Mem. 46, Geol. Soc. America, pt. 2, p. 21, pl. 11, figs, 1a, b, 2 a, b.

This species is reported in the northwestern Gulf of Mexico deeper than 1,000 m. It occurs in Cores 223, 235, 243, 246, 280 and surface samples 226 and 233.

Eponides pusillus Parr

(Plate 9, figures 5, 6)

Eponides pusillus Parr, 1950, B. A. N. Z., Antarctic Res. Exped. 1929—1931, ser. B, vol. 5, pt. 6, p. 360, pl. 14, figs. 16 a—c.

This species seems identical with Parr's except that the adults usually have 6 chambers instead of 4 or 5 as he describes. The species is described, however, from only five Recent specimens which may not be truly representative of it. *E. pusillus* resembles *E. turgidus* Phleger and Parker but has a less convex dorsal side and more chambers, the latter having usually 4 in the last-formed whorl. It is recorded off Tasmania at three stations at 122—155 m. depth. Due to its small size many specimens occur in the uncounted fine fractions and therefore the occurrences listed in the tables probably do not appear as widespread in the Atlantic as they actually are. The species occurs in Cores 236, 242, 243, 246, 248, 252, 257, 258, 280 and 281.

Eponides tumidulus (H. B. Brady)

(Plate 9, figures 7, 8)

Truncatulina tumidula H. B. Brady, 1884, Rep't. Voy. CHALLENGER, Zool. vol., 9, p. 666, pl. 95, figs. 8 a—d.

This species is reported from depths greater than 1,000 m. Like the previous species many specimens occur in the uncounted fine fractions. It is found in scattered cores and surface samples throughout the area.

Eponides umbonatus (Reuss) and variants

(Plate 9, figures 9, 10)

Rotalina umbonatus Reuss, 1851, Zeitschr. deutsch. Geol. Ges., vol. 3, p. 75, pl. 5, figs. 35 a—c.

Specimens show a variation in the character of the periphery from subacute to rounded. Those with a rounded periphery are considered to be variants as topotypes have a uniformly subacute one. Other characteristics remain constant. The species is reported from deeper than 42 m. in the North Atlantic. It has a widespread occurrence in cores and surface samples.

Osangularia cultur (Parker and Jones)

(Plate 9, figures 11, 16)

Planorbulina cultur Parker and Jones, 1865, Phil. Trans. Roy. Soc. London, p. 421, pl. 19, fig. 1.

This species is reported deeper than 920 m. in the North Atlantic and 600 m. in the Gulf of Mexico. It occurs in Cores 215, 221, 234, 238, 242, 246, 258, 267 and surface samples 224, 226, 267, ATLANTIS Sta. 4631 and 4633.

»Rotalia» beccarii (Linné) variants

(Plate 9, figures 12, 13, 14, 15, 17, 18)

Nautilus beccarii Linné, 1758, Syst. Nat., ed. 10, p. 710.

No typical specimens of this species are found but several variant forms occur in small numbers. These include Shupack's variety *sobrina* (plate 9, figures 14, 15) and forms that have been often referred to *»Rosalina parkinsoniana»* d'Orbigny (plate 9, figures 17, 18). In Core 221 specimens are found with a thicker test than Rimini, Italy, specimens, and with a more papillate ventral side (plate 9, figures 12, 13). Variant forms occur associated with displaced faunal assemblages in Cores 221, 252, 257 and 258.

»Rotalia» praegeri

(Heron-Allen and Earland)

(Plate 9, figures 19, 20, 21)

Discorbina praegeri Heron-Allen and Earland, 1913, Proc. Roy. Irish Acad., vol. 31, pt. 64, p. 122, pl. 10, figs. 8—10.

Specimens found in Core 290 were compared with material from the vicinity of Ireland. The variation within the two groups differs in that the core specimens include some with 10 chambers in the last-formed whorl whereas the Irish ones have a maximum of 7. In both cases the size of the ventral plugs varies greatly. The species is reported from the vicinity of the British Isles. Reports from other areas are not accompanied by figures and as this species may be confused very easily with *»R.» translucens* Phleger and Parker they are not included here.

»Rotalia» translucens Phleger and Parker

(Plate 9, figures 22, 23)

Rotalia translucens Phleger and Parker, 1951, Mem. 46, Geol. Soc. America, pt. 2, p. 24, pl. 12, figs. 11 a, b, 12 a, b.

This species varies from the previous one in being in mos tcases plano-convex, the dorsal side being flat, or very slightly convex. *»R». praegeri* has a convex dorsal side and flat or concave ventral side. *R. translucens* seldom has more than 5 chambers in the last-formed whorl. It is reported from the northwestern Gulf of Mexico from 25—1,000 m. It is asso-

ciated with displaced faunal assemblages in Cores 228 and 252.

Höglundina elegans (d'Orbigny)

(Plate 9, figures 24, 25)

Rotalia (*Turbinulina*) *elegans* d'Orbigny, 1826, Ann. Sci. Nat. vol. 7, p. 276, no. 54 (not *R. elegans* d'Orbigny, ibid., p. 272, no. 6). — Jones and Parker, 1860, Quart. Journ. Geol. Soc., vol 16, pl. 20, fig. 46.

This species is reported in the North Atlantic deeper than 42 m. It occurs in scattered cores and surface samples throughout the area.

Cancris cf. oblonga (Williamson)

(Plate 9, figures 26, 27)

Rotalina oblonga Williamson, 1858, Rec. Foram. Great Britain, p. 51, pl. 4, figs 98—100.

The few specimens which occur are small and cannot be identified with certainty. The maximum reported depth for *C. oblonga* in the North Atlantic is 200 m. The specimens are associated with displaced faunal assemblages in Cores 221 and 228.

Family AMPHISTEGINIDAE

Amphistegina lessonii d'Orbigny

(Plate 9, figures 28, 29)

Amphistegina lessonii d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 304, no. 3, pl. 17, figs. 1—4; Modèle, no. 98.

Juvenile specimens occur in displaced faunal assemblages in Cores 215, 248, 252 and 267. Most previous records for the species are from 0—90 m. depth in mid-latitudes.

Family CYMBALOPORIDAE

Tretomphalus atlanticus Cushman

(Plate 9, figures 30, 31)

Tretomphalus atlanticus Cushman, 1934, Contr. Cushman Lab. Foram. Res., vol. 10, pt. 4, p. 86, pl. 11, figs. 3 a—c; pl. 12, fig. 7.

Most reported occurrences are from the West Indian region in shallow water. No planktonic stages of this species occur in our material. Benthonic forms occur in Cores 228, 267 and surface sample 267.

Family CASSIDULINIDAE

Epistominella exigua (H. B. Brady)

(Plate 9, figures 35, 36)

Pulvinulina exigua H. B. Brady, 1884, Rep't. Voy. CHALLENGER, Zool., vol. 9, p. 696, pl. 103, figs. 13, 14.

This species is reported deeper than 117 m., with most records deeper than 275 m. It has a widespread occurrence in the cores and surface samples.

Epistominella (?) umbonifera (Cushman)

(Plate 9, figures 33, 34)

Truncatulina pygmaea H. B. Brady (not Hantken, 1875), 1884, Rep't. Voy. CHALLENGER, Zool. vol. 9, p. 666, pl. 95, figs. 9 a—c, 10.

Pulvinulinella umbonifera Cushman, 1933, Contr. Cushman Lab. Foram. Res., vol. 9, pt. 4, p. 90, pl. 9, figs. 9 a—c.

? *Eponides bradyi* Earland, 1934, DISCOVERY Rep'ts., no. 10, p. 187, pl. 8, figs. 36—38.

Pulvinulinella sp. A, Cushman and Henbest, 1940, U. S. Geol. Surv. Prof. Paper 196—A, p. 36, pl. 10, fig. 5.

Cushman's holotype of this species is a very poor, small specimen but is identical with small specimens of the species in our material. Additional specimens from the same general locality from which Cushman described his species are large, well-developed forms, also identical with ours. The species attains a maximum diameter of 0.6 mm. Cushman describes it as having a maximum of 6 chambers in the adult whorl but there may be as many as 9. The sutures often appear as white lines

if the test is sufficiently transparent to reveal a part of the septa; in other specimens they appear as dark, narrow lines.

This species is retained in the genus *Epistominella* with considerable doubt. In many respects it most closely resembles the genus *Nuttallides* Finlay especially as regards the nature of the aperture, which starts near the umbilical region and turns into the plane of coiling near the periphery, extending only a short distance into the chamber. In some specimens the aperture is much closer to the *Eponides* — type aperture. This is in line with Earland's statement in his description of *Eponides bradyi* that Brady's »*Truncatulina pygmaea* Hantken» should be placed in the genus *Eponides*. Brady's figured specimens appear to be identical with ours although the nature of the aperture cannot be seen very clearly. Earland's species *Eponides bradyi* is placed in the synonymy tentatively as his types could not be checked. Cushman's (1927, p. 165, pl. 5, figs. 11—13) species *Epistominella bradyana* in whose synonymy he places Brady's »*Truncatulina pygmaea*» appears from the figures to be a different form with a finely perforate wall and a true *Epistominella* type of aperture. The types of this species have not been studied. *E. umbonifera* is reported from the Atlantic in deep water. It has a widespread occurrence in cores and surface samples.

Cassidulina carinata A. Silvestri

(Plate 9, figures 32, 37)

Cassidulina laevigata d'Orbigny var. *carinata* A. Silvestri, 1896, Accad. Pont. Nuovi Lincei, Mem. 12, p. 104, pl. 2, fig. 10 (*C. laevigata* in explanation of plate).

Our specimens are similar to ones from the Pliocene of Siena, Italy. The species named *C. laevigata* var. *carinata* by Cushman (1922, p. 124) and later changed to *C. neocarinata* by Thalmann (1950, p. 44) is different and apparently not so widely distributed. Cushman's species has a long, narrow apertural face and slit-like aperture with a narrow tooth. *C. carinata* has a broader apertural face and tooth, is less compressed and is more coarsely perforate. Many of the forms which have been referred to Cushman's form should be referred to Silvestri's. Neither species shows much resemblance to *C. laevigata* which has a more rounded apertural face and very small aperture, set at an angle and without the plate-like tooth. The records of these various species are so confused that it is impossible to give the distribution accurately. Brady's (1884, pl. 54, fig. 3) figure of »*C. laevigata*» from west of Ireland is undoubtedly *C. carinata*. It has also been observed in Mediterranean and Arctic material. Specimens of *C. neocarinata* occur on the western Atlantic continental shelf and the species is common in the Gulf of Mexico at depths of less than 1,000 m. It is not found in the deep sea cores and is perhaps confined to shallower depths in the Atlantic as it was in the Gulf of Mexico (Phleger, 1951, p. 45. — listed as *C. laevigata* var. *carinata*). *C. carinata* is widely distributed in the southern cores and occurs in Cores 288, 289, 292, 293 and 296 in the northern area. It also occurs in surface samples 224 and SAN PABLO Sta. 3—47.

Cassidulina crassa d'Orbigny

(Plate 10, figure 1)

Cassidulina crassa d'Orbigny, 1839, Voy. Amér. Mérid., vol. 5, pt. 5, »Foraminifères», p. 56, pl. 7, figs. 18—20. — H. B. Brady, 1884, Rep't. Voy. CHALLENGER, Zool., vol. 9, p. 429, pl. 54, fig. 5.

Included in the counts of this species in some of the northern group of cores are specimens of *C. islandica* Nørvang. The latter species is less compressed than *C. crassa* and has a thin plate-like tooth partially concealing the aperture. *C. crassa* is reported from 73—4300 m. in the North Atlantic and at similar depths in the Gulf of Mexico. *C. islandica* is

reported off Iceland at 38—220 m. *C. crassa* occurs in scattered cores throughout the area but never in abundance. It is found in only three surface samples: ATLANTIS Sta. 4631, SAN PABLO Sta. 3—47 and REHOBETH Sta. 3—32.

Cassidulina curvata Phleger and Parker

(Plate 10, figure 2)

Cassidulina curvata Phleger and Parker, 1951, Mem. 46, Geol. Soc. America, pt. 2, p. 26, pl. 14, figs. 5 a, b.

This species is easily confused with *C. laevigata*. One important difference between the two, not mentioned in the original description, is in the apertural characteristics. The aperture of *C. curvata* is in the plane of coiling with no protruding apertural face visible from the side. *C. laevigata* has a rounded apertural face into which the aperture projects at an angle. *C. curvata* is reported as *C.* sp. (Parker, 1948, p. 237) deeper than 90 m. on the western Atlantic continental shelf. It is associated with a displaced faunal assemblage in Core 252.

Cassidulina norcrossi australis Phleger and Parker

(Plate 10, figure 3)

Cassidulina norcrossi australis Phleger and Parker, 1951, Mem. 46, Geol. Soc. America, pt. 2, p. 27, pl. 14, figs. 8 a, b, 9, 10.

This species is reported from 200—700 m. in the northwestern Gulf of Mexico. A few specimens are found associated with displaced faunal assemblages in Cores 252 and 257.

Cassidulina reflexa Galloway and Wissler

(Plate 10, figures 6, 7)

Cassidulina reflexa Galloway and Wissler, 1927, Journ. Pal., vol. 1, no. 1, p. 80, pl. 12, fig. 13.

The North Atlantic species is very similar to Galloway and Wissler's, described from the Pleistocene of California, although a few very large specimens measuring over 1.00 mm. in length are found. The holotype, not seen, is 0.32 mm. in length and most of the specimens found are comparable in size. *C. reflexa* is reported from the Middle Miocene of Haiti by Coryell and Rivero (1940, p. 342). Specimens from the Miocene of Haiti collected by W. P. Woodring are identical with our specimens. The species is found in the lower part of Cores 233 and 238.

Cassidulina subglobosa H. B. Brady

(Plate 10, figure 4)

Cassidulina subglobosa H. B. Brady, 1881, Quart. Journ. Micr. Sci., vol. 21, p. 30 (60); 1884, Rep't. Voy CHALLENGER, Zool., vol. 9, p. 430, pl. 54, figs. 17 a—c.

This species is very variable in size and may be more properly defined as a »species group». It is reported from depths of 37—1610 m., usually deeper than 185 m. It is widely distributed throughout the cores and surface samples.

Cassidulina sp. 1

(Plate 10, figure 5)

This species resembles *G. subglobosa* but is somewhat compressed, with less-inflated chambers. It is more common in the Mediterranean than the North Atlantic where it is found associated with a displaced faunal assemblage in Core 215.

Cassidulina sp. 2

(Plate 10, figures 8, 9)

This species has not been previously described. It resembles *C. palmerae* Bermudez and Acosta in its reticulate ornamentation but differs in the character of the aperture which lies in the plane of coiling, in the acuteness of the periphery at the apex of the test, and in other respects. It most closely resembles *C. favus* (H. B. Brady)

but is more highly convex. A few specimens are found in Cores 233 and 238, in the former associated with the presumed Miocene assemblage.

Cassidulinoides mexicana (Cushman)

(Plate 10, figures 10, 11)

Cassidulina mexicana Cushman, 1922, Bull. 104, U. S. Nat. Mus., pt. 3, p. 131, pl. 24, fig. 5.

This species is reported from a depth of 40 m. off the coast of Florida and from 1488 m. in the Caribbean Sea. The holotype is identical with our smaller specimens. Cushman described the species from only two specimens and was therefore ignorant of the range of variation of the form. Specimens from Core 221, sample 56, range in length from 0.29—0.86 mm. Specimens are found associated with displaced faunal assemblages in Cores 221 and 248.

Ehrenbergina trigona Goës

(Plate 10, figures 12 a, b, 13)

Ehrenbergina serrata Reuss var. *trigona* Goës, 1896, Bull. Mus. Comp. Zool., vol. 29, no. 1, p. 49.

Textularia triquetra Goës (not von Münster, 1838), 1882, Kongl. Svensk. Vet. Akad. Handl., vol. 19, no. 4, p. 83, pl. 6, figs. 183, 184.

Ehrenbergina serrata H. B. Brady (not Reuss, 1850), 1884, Rep't. Voy. CHALLANGER, Zool., vol. 9, p. 434, pl. 55, figs. 2, 3, (not 4—7).

Ehrenbergina bradyi Cushman, 1922, Bull. 104, U. S. Nat. Mus., pt. 3, p. 134, pl. 26, fig. 5; 1927, Proc. U. S. Nat. Mus., vol. 70, art 16, p. 5, pl. 2, figs. 1 a—c.

There has been much confusion between this species and the one following (*E. undulata* Parker, n. sp.). Goës placed Brady's figures of *E. serrata* in the CHALLENGER Report in the synonymy under his species, but included all of them. He placed his own reference to *Textularie triquetra* of 1882 after Brady's. His figured specimen clearly refers to the same species figured by Brady (pl. 55, figs. 2, 3). In 1922 Cushman described *E. bradyi* whose holotype, seen at the U. S. National Museum in Washington, D. C., is definitely referable to Goës' species. Cushman later confirmed this in 1927 by placing Brady's pl. 55, figs. 2, 3, 5(?) only in the synonymy under his species *E. bradyi*, although in 1922 he placed Brady's pl. 55, figs. 6, 7 only in the synonymy. Many later authors have called this species *E. bradyi*. *E. trigona* is characterized by its trigonal shape, the rather broadly divided central furrow whose sharp boundaries terminate in spines at each chamber, and the concave sides and concave to flat dorsal side. Goës reports the species from deeper than 549 m. The form referred by Colom (1950, p. 28) to *E. bradyi* is probably *E. trigona* and is reported in his facies from 150—475 m. off the coast of Africa. E. *trigona* occurs in Cores 238, 242 and 279.

Ehrenbergina undulata Parker, n. sp.

(Plate 10, figures 14, 15 a, b, 16)

Ehrenbergina trigona Cushman 1922 (not Goës, 1896), Bull. 104, U. S. Nat. Mus., pt. 3, p. 135, pl. 26, fig. 4; 1927, Proc. U. S. Nat. Mus., vol. 70, art. 16, p. 6, pl. 2, fig. 3; 1936, Bull. Geol. Soc. America, vol. 47, p. 425, pl. 3, figs. 9 a, b.

Test large, triangular in cross-section in early portion of test, later compressed, the early portion on the ventral side with a very narrow central furrow formed from the carinated margins of the chambers, sometimes merging into a single keel, with occasionally on some specimens a projecting spine, young forms sometimes showing the keels throughout the test, the sides of test carinate with a heavy spine at each chamber; chambers non-inflated in early portion, later slightly inflated; sutures limbate, flush with surface in early portion, later slightly depressed; wall smooth except

for a few spines and occasional tubercles on the initial portion of test and the occasional spines on the central furrow and the marginal spines, finely perforate; aperture normal. Maximum length 0.83 mm.; maximum width 0.75 mm.

The holotype is from Core 290, ≠ 21 (219.5—220 cm. from top), Lat. 41° 35′ N., Long. 29° 37′ W at a depth of 1995 m.

This species varies in the amount of the test showing a sharply triangular cross-section. It differs from *E. trigona* in not having the deep, rather broad central furrow on the ventral side decorated with a spine at each chamber, in the less deeply concave areas on each side of the central portion of the ventral side, in the somewhat convex dorsal side, non-trigonal later portion of the test, and in having the initial portion of the test decorated with spines. Cushman reports it from depths greater than 33 m. The figured specimens of all the references given in the synonymy have been studied. The specimens referred to *E. serrata* Reuss by Cushman and Henbest (1940, pl. 10, fig. 10) from North Atlantic deep-sea cores are also referable to *E. undulata*. *E. undulata* is widely distributed in the cores, except for those off the coast of Brazil, and is found in surface sample ATLANTIS Sta. 4631.

Family CHILOSTOMELLIDAE

Rotamorphina laevigata (Phleger and Parker)

(Plate 10, figures 17, 23)

Valvulineria laevigata Phleger and Parker, 1951, Mem. 46, Geol. Soc. America, pt. 2, p. 25, pl. 13, figs. 11 a, b, 12 a, b.

This species is referred to the wrong genus by Phleger and Parker. There are usually 5 chambers, occasionally 4 or 6, in the adult whorl. The distinction between Finlay's genera *Quadrimorphina* and *Rotamorphina* seems a rather arbitrary one. Future investigation may lead to a combination of the two. *R. laevigata* is reported deeper than 300 m. in the North Atlantic by Parker (1948, p. 225) as *Valvulineria* sp. and by Cushman (1931, p. 44) as *Eponides exigua* (H. B. Brady) (not *Pulvinulina exigua* H. B. Brady). It occurs in Cores 221, 248 and surface samples 224, 225 and 228.

Chilostomella oolina Schwager

(Plate 10, figure 18)

Chilostomella oolina Schwager, 1878, Boll. Com. Geol. Ital., vol. 9, p. 527, pl. 1, fig. 16.

This species is reported in most cases deeper than 200 m. although there are a few shallow occurrences: It is widely distributed in the cores but is not found in the surface samples.

Pullenia bulloides (d'Orbigny)

(Plate 10, figure 19)

Nonionina bulloides d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 293, no. 2; 1846, Foram. Foss. Bass. Tert. Vienne, p. 107, pl. 5, figs. 9, 10.

Young specimens of this species are frequently assymetrical. This feature does not appear in adults. The species is widely reported, and has a widespread occurrence in the cores and surface samples.

Pullenia quinqueloba (Reuss)

(Plate 10, figure 20)

Nonionina quinqueloba Reuss, 1851, Zeitschr. deutsch. Geol. Ges., vol. 3, p. 71, pl. 5, fig. 31.

This species is reported deeper than 80 m. but is found most commonly deeper than 940 m. It has a widespread occurrence in cores and surface samples.

Pullenia cf. riveroi Bermudez

(Plate 10, figure 21)

Pullenia riveroi Bermudez, 1939, Mem. Soc. Cubana Hist. Nat., vol. 13, no. 1, p. 11, pl. 2, figs. 1—6.

North Atlantic specimens are referred tentatively to this species. They appear to be

identical with Bermudez' figure 4 in the above reference. None of the specimens resemble his other figured types. Bermudez says that figure 4 represents a juvenile specimen. Adult specimens are very broad in apertural view, and inflated. He reports the species off Cuba deeper than 1,042 m. It occurs in Cores 252 and 267 associated with displaced faunal assemblages, and in surface sample 267.

Pullenia sp.

(Plate 10, figure 22)

This species occurs only in small numbers. It is more compressed than the previous species, with a lobulate periphery and 6—7 chambers in the adult whorl. It somewhat resembles *P. salisburyi* R. E. Stewart and K. C. Stewart but has a more rounded periphery. It is apparently a new species but insufficient specimens occur in any one sample to adequately describe it. *Pullenia* sp. has a widespread occurrence in cores and is found in surface samples 257, 258, 261, 267, 280, 284, 285, ATLANTIS Sta. 4637, 4739, 4742, and in REHOBETH Sta. 3—29.

Family ANOMALINIDAE

Anomalina balthica (Schroeter)

(Plate 10, figures 24, 25)

Nautilus balthicus, 1783, Einleitung Conch. Kenntn. vol. 1, p. 20, pl. 1, fig. 2.

Nonionina elegans Williamson (not *Anomalina elegans* d'Orbigny, 1826), 1858, Recent Foram. Great Britain, p. 35, pl. 3, figs. 74, 75.

This identification has been generally accepted by authors since Cushman (1931, p. 108) revived it. It is somewhat questionable owing to the great discrepancy in the number of chambers in the last-formed whorl of the form figured by Schroeter and the forms later referred to it. Schroeter's figure shows 24 chambers in the last-formed whorl, while an examination of numerous specimens from various localities gives a maximum of 11. The species is recorded from numerous localities near the British Isles and elsewhere in the eastern Atlantic to a depth of 2,981 m. Colom (1950) records it as frequent to abundant in his deepest facies, 300—878 m., off the west coast of Africa. It is associated with displaced faunal assemblages in Cores 221 and 228 off Africa and the Cape Verde Islands.

Anomalina sp.

(Plate 10, figures 26, 27, 28)

This species resembles Brady's figures in the CHALLENGER Report (Brady, 1884, pl. 94, figs. 4, 5) of »*Anomalina grosserugosa*», but appears to be more finely perforate on the involute side. Brady's species is not the same as Gümbel's and is probably a new species as pointed out by Thalmann (1933, p. 254). A study of Brady's material might reveal that our species is the same as his. It has the following characteristics: a broadly rounded periphery, six chambers in the last-formed whorl, a coarsely perforate evolute side and smooth, more finely perforate involute side, a maximum diameter of 0.6 mm. The species occurs in very small numbers in many of the cores throughout the area, but there is insufficient material to fully reveal its characteristics and variation.

Planulina ariminensis d'Orbigny

(Plate 11, figures 3, 4)

Planulina ariminensis d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 280, no. 1, pl. 14, figs. 1—3.

Most of the specimens are small. They resemble Rimini specimens although the punctae are not well defined due to poor preservation. *P. ariminensis* is reported deeper than 275 m., but is found in shore sands at Rimini, Italy. It occurs in Cores 215 and 290.

Planulina wuellerstorfi (Schwager)

(Plate 11, figures 1, 2)

Anomalina wuellerstorfi Schwager, 1866, Novara Exped., Geol. Theil., vol. 2, p. 258, pl. 7, figs. 105, 107.

This species is very variable in North Atlantic material. The greatest variation is in the amount of compression of the test, some of the specimens being very convex on the involute side. These convex forms are probably referable to *P. bradyi* Tolmachoff but have not been differentiated as such in our material. The species lies in the transition zone between the genera *Planulina* and *Cibicides*. It is reported in the Atlantic deeper than 630 m. and has a widespread occurrence in the cores and surface samples.

Laticarinina pauperata (Parker and Jones)

(Plate 11, figure 5, 6)

Pulvinulina repanda var. *menardii* subvar. *pauperata* Parker and Jones, 1865, Phil. Trans. Roy. Soc. London, vol. 155, p. 395, pl. 16, figs. 50, 51 a, b.

This species is reported deeper than 200 m. It is found at low frequencies in scattered cores and surface samples throughout the area.

Cibicides kullenbergi Parker, n. sp.

(Plate 11, figures 7, 8)

Test large, biconvex, the evolute side much less convex than the involute, composed of three whorls, periphery acute with a narrow keel, regular; chambers distinct, 11—13 in the last-formed whorl, meeting at the center on the involute side in an area of clear shell material of varying size which does not protrude to form a raised umbo; sutures flush with the surface on both sides, curved; wall thick, partially translucent depending on the state of preservation of the specimens, finely perforate on the involute side, with a few large punctae rather widely spaced on each chamber on the evolute side; aperture peripheral, extending into the evolute side. Maximum diameter 0.8 mm.; thickness 0.43 mm.

The holotype is from REHOBETH Sta. 3—38, Lat. 36° 34′ N, Long. 38° 15′ W, at a depth of 3109 m.

This species differs from *C. robertsonianus* (H. B. Brady) in the less translucent wall, fewer chambers in the adult form, broader and fewer whorls, more curving sutures on the evolute side and the more widely spaced, large punctae on the evolute side. It differs from *C. mundula* (Brady, Parker and Jones) in its much larger size, the greater convexity of the involute side and in the aperture which extends onto the evolute side even in young specimens. It is common in many of the cores, mostly in the northern group, and is widespread in the surface samples. It appears to be a true deep-sea form.

Cibicides lobatulus (Walker and Jacob)

(Plate 11, figures 9, 14)

Nautilus lobatulus Walker and Jacob, 1798, Adams Essays, Kannmacher's ed., p. 642, pl. 14, fig. 36.

This species is widely reported in the North Atlantic. It is in many cases associated with displaced faunal assemblages in the cores. It occurs in Cores 215, 221, 228, 233, 235, 252 and 257.

Cibicides cf. **refulgens** Montfort

(Plate 11, figures 10, 11)

Cibicides refulgens Montfort, 1808, Conch. Syst., vol. 1, p. 123. »Hammonia *Balanus* seu *Balanoidea*», Soldanii, 1789, Test., vol. 1, pt. 1, p. 58, pl. 46, figs. *nn*, *oo*.

North Atlantic specimens resemble those from Rimini except for their smaller size (maximum diameter 0.47 mm.). Brady (1884,

p. 659) reports the species between. N. Lats. 47° and 62° at depths from 82—4390 m. Specimens occur associated with displaced faunal assemblages in Cores 215, 248, 252, 257, and 267 south of this area.

Cibicides robertsonianus (H. B. Brady)

(Plate 11, figures 15, 16, 17)

Truncatulina robertsoniana H. B. Brady, 1881, Quart. Journ. Micr. Sci., vol. 21, p. 65; 1884, Rep't. Voy. CHALLENGER, Zool., vol. 9, p. 664, pl. 95, figs. 4 a—c.

Records for this species in the North Atlantic are from depths greater than 700 m. In the Gulf of Mexico it is recorded deeper than 450 m. It is widespread in the cores and surface samples.

Cibicides sp.

(Plate 11, figures 18, 22)

This species is more compressed than *C. lobatulus*, non-lobulate in the earlier part of the keeled test but with the last-formed chambers irregular and flaring. The sutures are limbate. The species occurs in small numbers in cores and surface samples throughout the area.

Cibicidina rhodiensis (Terquem)

(Plate 11, figures 12, 13)

Truncatulina rhodiensis Terquem, 1878, Mém. Soc. Géol. France, ser. 3, vol. 1, pt. 3, p. 21, pl. 1 (6), figs 26 a—c.

North Atlantic specimens are identical with ones from the Mediterranean. Said (1949, p. 42) in comparing this species with *C. americanus* (Cushman) states that it differs in having a narrow keel. He has obviously referred to the »*Truncatulina americana*» described by Cushman (1918 a, p. 63, pl. 20, figs. 2, 3; pl. 21, fig. 1) from the Miocene of the Atlantic Coastal Plain. The holotype of this species has the catalogue no. U. S. N. M. 325328. In the same year Cushman (1918, p. 68, pl. 23, figs. 2 a—c) named a species »*Truncatulina americana*» from the Culebra Formation of Panama, whose holotype has the catalogue no. U. S. N. M. 324665. On the basis of this earlier number it seems reasonable to give priority to the Panama species. It is a keeled form very similar to Terquem's. Said records *C. rhodiensis* in the Red Sea from 30—512 m. It is found associated with displaced faunal assemblages in Cores 221 and 252.

Family PLANORBULINIDAE

Planorbulina mediterranensis d'Orbigny

(Plate 11, figures 20, 21)

Planorbulina mediterranensis d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 280, no. 2, pl. 14, figs. 4—6 bis; Modèles, no. 79.

This species is reported to a depth of 1160 m., but is more common at less than 150 m. It occurs in Cores 215, 221 and 228 associated with displaced faunal assemblages.

Family RUPERTIIDAE

Rupertia stabilis Wallich

(Plate 11, figure 19)

Rupertia stabilis Wallich, 1877, Ann. Mag. Nat. Hist., ser. 4, vol. 19, p. 502, pl. 20, figs. 1—13.

This species is reported from scattered stations in various parts of the North Atlantic from 9—2515 m. It occurs in Cores 233, 267 and 290.

Planktonic Foraminifera in Surface Sediment Samples

Distribution

The populations of planktonic Foraminifera were analyzed in 53 samples of surface sediment rather generally distributed in this area of the Atlantic. These samples were obtained with the short coring tube described by Phleger (1951, p. 3) and it is assumed that the faunas

represent the modern accumulation of tests. The samples taken are 1 cm. in thickness, and although the material at the surface may be considered to accurately represent modern materials, the lower part of each sample was deposited at some time in the past.

A problem in the use of bottom samples is that the planktonic fauna occurring in the sediment did not necessarily live in the water directly above the position of any sample. Planktonic Foraminifera are transported by the water masses which they inhabit, and they may be transported during life or after death. A population from a sediment may have been transported a considerable distance before deposition. Also, a population may be introduced by a water mass representing a foreign environment, the specimens killed, and deposited. Ecological interpretations from sediment samples may be misleading unless the distribution and movements of water masses are taken into account. All these qualifications should be considered in interpreting data on distribution of planktonic Foraminifera from sediments.

The most realistic distribution method of study of the ecology of planktonic Foraminifera is from plankton tows collected from all depths of water. This is a laborious procedure, both in the field and in the laboratory, and has not been possible in this study. The use of faunas from bottom samples is the best approximation which can be made at the present time.

The distributions of the principal planktonic species are plotted on Figures 3—19. Total populations are plotted on Figure 20 for those samples which were equal in size. Some of the samples furnished were of different sizes and are not included in any population counts. The distribution of each planktonic species in these bottom samples is discussed below. The generalizations about distributions apply only to the occurrences in the present suite of samples, unless otherwise specified. The samples with low total populations (see Figure 20) are generally disregarded in the following discussions.

Globigerina bulloides is recorded from all stations but the frequencies have significant differences. It is most abundant north of approximately 30° N Lat., where the frequencies range from 24 % to 67 % of total population with an average frequency of 30—40 %. South of 30° N Lat. the significant frequencies are less than 10 % except at three stations near the west coast of Africa, between Cape Verde and Cape Blanco, where frequencies are 14—26 %. Frequencies are generally 5 % or less south of approximately 15° N. Lat. The frequency boundary at about 30° N. appears to be rather pronounced, but this may be an effect of the spacing of the samples over such a wide area.

Globigerina eggeri is recorded from all but six stations. The highest frequencies occur south of 20° N. Lat. where it may be more than 25 % of the population. In the equatorial mid and western Atlantic the frequencies are somewhat lower. Significant percentages occur at the mid-Atlantic stations between approximately 35° N. Lat. and 42° N. Lat.

Globigerina inflata seems to be a mid-latitude species, being essentially restricted to north of 15° N. Lat. The highest frequencies occur at three stations off west Africa between Cape Verde and Cape Blanco where they are 30—34 %. Elsewhere north of the Fifteenth Parallel it ranges between about 10—20 % at the majority of stations. This species is recorded at very low frequencies from only two of the present stations south of 15° N. Lat.

Globigerina pachyderma has a distinctly northern distribution, being essentially restricted to north of 35° N. Lat. and with no record south of about 27° N. Lat. Frequencies are generally low, but there is an apparent increase at about 45° N. Lat.

Globigerinella aequilateralis is universally distributed at most stations, except the two

Fig. 3. Distribution of *Globigerina bulloides* d'Orbigny in surface sediment samples. First number at each station is percent of total population of planktonic Foraminifera second number, in parentheses, is estimated actual number of specimens.

Fig. 4. Distribution of *Globigerina eggeri* Rhumbler in surface sediment samples. First number at each station; is percent of total population of planktonic Foraminifera; second number, in parentheses, is estimated actual number of specimens.

Fig. 5. Distribution of *Globigerina inflata* d'Orbigny in surface sediment samples. First number at each station is percent of total population of planktonic Foraminifera; second number, in parentheses, is estimated actual number of specimens.

Fig. 6. Distribution of *Globigerina pachyderma* (Ehrenberg) in surface sediment samples. First number at each station is percent of total population of planktonic Foraminifera; second number, in parentheses, is estimated actual number of specimens.

Fig. 7. Distribution of *Globigerinella aequilateralis* (H. B. Brady) in surface sediment samples. First number at each station is percent of total population of planktonic Foraminifera; second number, in parentheses, is estimated actual number of specimens.

Fig. 8. Distribution of *Globigerinita glutinata* (Egger) in surface sediment samples. First number at each station is percent of total population of planktonic Foraminifera; second number, in parentheses, is estimated actual number of specimens.

Fig. 9. Distribution of *Globigerinoides conglobata* (H. B. Brady) in surface sediment samples. First number at each station is percent of total population of planktonic Foraminifera; second number, in parentheses, is estimated actual number of specimens.

Fig. 10. Distribution of *Globigerinoides rubra* (d'Orbigny) in surface sediment samples. First number at each station is percent of total population of planktonic Foraminifera; second number, in parentheses, is estimated actual number of specimens.

Fig. 11. Distribution of *Globigerinoides sacculifera* (H. B. Brady) in surface sediment samples. First number at each station is percent of total population of planktonic Foraminifera; second number, in parentheses, is estimated actual number of specimens.

Fig. 12. Distribution of *Globorotalia hirsuta* (d'Orbigny) in surface sediment samples. First number at each station is percent of total population of planktonic Foraminifera; second number, in parentheses, is estimated actual number of specimens.

Fig. 13. Distribution of *Globorotalia menardii* (d'Orbigny) in surface sediment samples. First number at each station is percent of total population of planktonic Foraminifera; second number, in parentheses, is estimated actual number of specimens.

Fig. 14. Distribution of *Globorotalia punctulata* (d'Orbigny) in surface sediment samples. First number at each station is percent of total population of planktonic Foraminifera; second number, in parentheses, is estimated actual number of specimens.

Fig. 15. Distribution of *Globorotalia scitula* (H. B. Brady) in surface sediment samples. First number at each station is percent of total population of planktonic Foraminifera; second number, in parentheses, is estimated actual number of specimens.

Fig. 16. Distribution of *Globorotalia truncatulinoides* (d'Orbigny) in surface sediment samples. First number at each station is percent of total population of planktonic Foraminifera; second number, in parentheses, is estimated actual number of specimens.

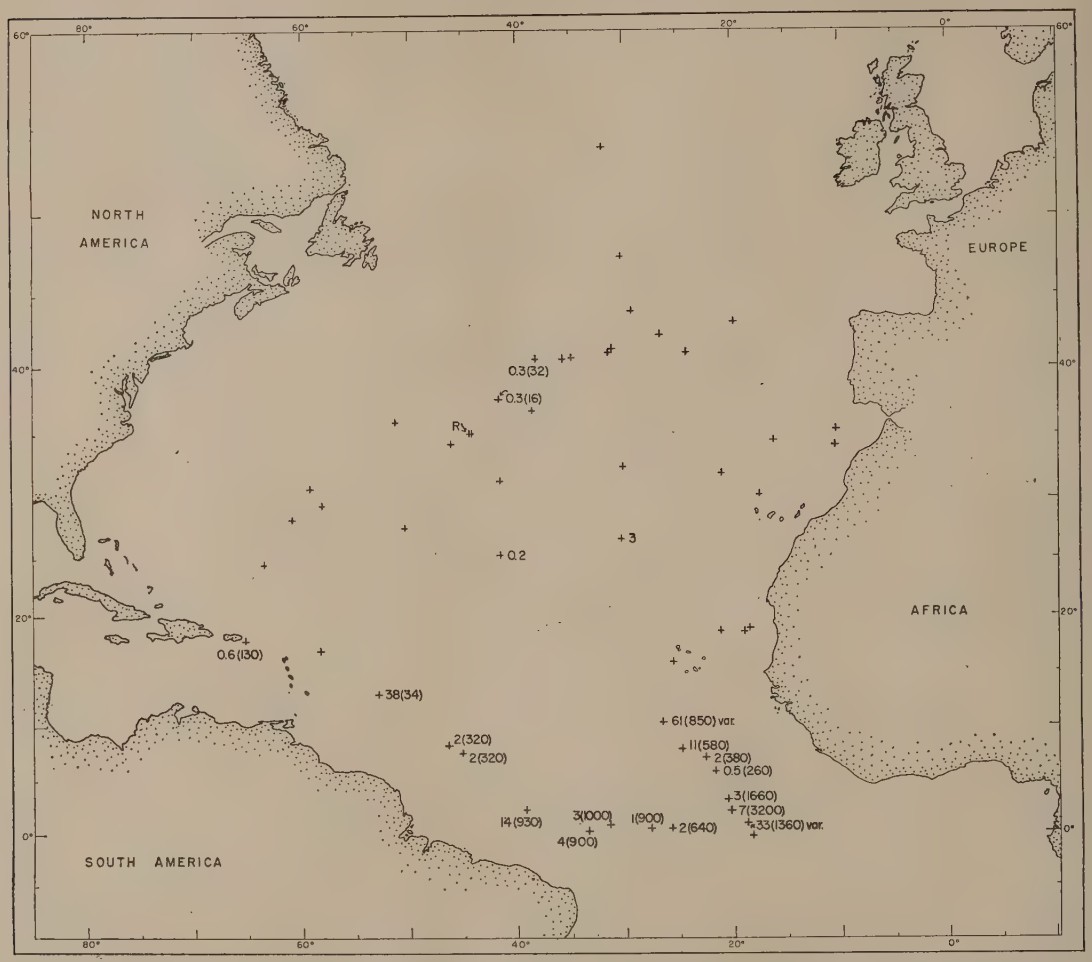

Fig. 17. Distribution of *Globorotalia tumida* (H. B. Brady) in surface sediment samples. First number at each station is percent of total population of planktonic Foraminifera; second number, in parentheses, is estimated actual number of specimens.

Fig. 18. Distribution of *Orbulina universa* d'Orbigny in surface sediment samples. First number at each station is percent of total population of planktonic Foraminifera; second number, in parentheses, is estimated actual number of specimens.

Fig. 19. Distribution of *Pulleniatina obliquiloculata* (Parker and Jones) in surface sediment samples. First number at each station is percent of total population of planktonic Foraminifera; second number, in parentheses, is estimated actual number of specimens.

Fig. 20. Total populations of planktonic Foraminifera in surface sediment samples.

northernmost ones, at low frequencies (4 % or less).

Globigerinita glutinata is generally distributed in the region at the majority of stations, with most frequencies 5 % or less.

Globigerinoides conglobata occurs at the majority of stations south of 40° N. Lat. The usual frequencies are 1 % or less.

Globigerinoides rubra is present at every station at relatively high frequencies, 10—65 %, except at the two northernmost stations where it is less than 1 % of the fauna. It may be most characteristic of the areas south of about 42° N. Lat.

Globigerinoides sacculifera is universally distributed except at the two northernmost stations. Frequencies are much higher south of approximately 10° N Lat. where they average more than 30 % at most stations. Frequencies are much lower north of this latitude where they are generally less than 10 %. North of approximately 35° N Lat. they are 3 % or less at most stations.

Globorotalia hirsuta appears to be characteristic of areas north of 30° N Lat., where it is 2—8 % of the fauna at each station. It is less than 1 % of the fauna at most of the stations between 10° and 30° N Lat., and it is not recorded south of 10° N Lat.

Globorotalia menardii is largely restricted to south of about 20° N Lat. where it occurs at frequencies of 5—20 %. It is recorded from nine mid-Atlantic stations between about 25° and 40° N. Lat. at frequencies of 2 % or less.

Globorotalia punctulata is recorded at most stations south of 20° N. Lat., generally at frequencies of 1 % or less. It is recorded from approximately half of the stations north of 20° N. Lat. at frequencies less than 1 %.

Globorotalia scitula is present in low percentages in the majority of the samples studied. The frequencies are somewhat higher north of about 32° N. Lat. (up to 6 %) than in the south, where they are all lessth an 1 %.

Globorotalia truncatulinoides is recorded from almost every station. It has higher frequencies between about 25° N. Lat., and 42° N. Lat., where it is 3—20 % of the population. South of 20 % N. Lat. the frequencies are distinctly lower than farther north, being 2 % or less of the population.

Globorotalia tumida is essentially restricted to south of about 13° N. Lat. where it occurs at variable but relatively high frequencies, generally about 10 % or less but as high as 61 % at one station. It is recorded at low frequencies (less than 1 %) from 5 stations in the mid-Atlantic between 20° and 40° N. Lat.

Orbulina universa is recorded from essentially every station, constituting a low percentage of the fauna (usually 2 % or less).

Pulleniatina obliquiloculata occurs at every station south of approximately 13° N. Lat. The percentages in this southern area average about 2—5 % but are as high as 15 %. It also occurs at several more northern stations but at distinctly lower frequencies, generally less than 1 %.

Discussion

In evaluating the distributions described above and shown on Figures 3—19, the density and locations of the sample stations should be taken into account. Only 53 samples were obtained, and 3 of them are unreliable because of the small populations. It is obviously not valid to make far-reaching, definite conclusions based upon such a low-density sampling especially as there are considerable variations in the Foraminifera populations of samples taken nearby. This is perhaps less striking in the deep ocean basins than in nearshore areas where conditions are more variable over short distances. Samples are difficult and expensive to obtain from the deep-sea for obvious technical reasons, and the number of samples available is thus limited. The quality of samples is another limiting factor.

The frequencies of the present planktonic species seem to show geographic trends which are consistent. This suggests that it is valid to use the present samples for making limited generalizations. It also strongly suggests that the samples are comparable in method of collection and that even though the faunas may not all be modern they are at least like the modern assemblage.

Previous studies of distributions of planktonic faunas from North and equatorial Atlantic sediment samples are as follows:

Schott (1935) has reported the distributions in surface sediment samples and plankton tows from the equatorial Atlantic collected by the METEOR Expedition. Cushman and Henbest (1940) report the faunas from 10 cores in the northern area. Phleger (1942) lists faunas from a part of the western continental slope, and Parker (1948) from the adjacent continental shelf. Ovey (Wiseman and Ovey, 1950) gives the faunas from nine scattered localities in the North Atlantic. Additional information can be obtained from Brady (1884) and Cushman (1924, 1931). The distributions given in these papers are quite similar to those shown in the present study, and in general this previous work supplements the present data.

The distributions of many of the planktonic species show variations with latitude as described above. These are not sharp, but are gradational. A few generalized types of distribution are listed below:

1. The following species seem to be characteristic of low latitudes, less than 20° N. Lat., where they occur at relatively high frequencies; they also occur in low frequencies at a few stations in mid-latitudes in the central Atlantic:

   Globorotalia menardii
   G. tumida
   Pulleniatina obliquiloculata

2. The following species occur in much greater abundance in low latitudes than in mid-latitudes although they occur at most of the stations:

   Globigerina eggeri
   Globigerinoides sacculifera

3. *Globigerina pachyderma* is confined to high and mid-latitudes.

4. The following species are more abundant in mid-latitudes although they also occur in low latitudes:

   Globigerina bulloides
   G. inflata
   Globorotalia hirsuta
   G. scitula
   G. truncatulinoides

5. The following species are universally distributed in approximately uniform frequencies within the area covered in this report:

   Globigerinella aequilateralis
   Globigerinita glutinata
   Globigerinoides conglobata
   G. rubra
   Orbulina universa

There is an approximate correlation between distribution of surface isotherms and latitude. The distribution of the mean sea surface temperatures in the North Atlantic for August and February is shown on Figure 21, based upon the sea surface temperature charts compiled by the U. S. Hydrographic Office. It should be emphasized that while these charts are statistically correct they are broad generalizations and should be evaluated as such. They do not show actual and extreme variations in surface temperatures which undoubtedly are of primary importance in regulating the distribution of organisms such as the planktonic Foraminifera. Moreover, they do not give information on the vertical distribution of temperature which Phleger's (1951) meagre data suggest is of importance in affecting distribution of planktonic Foraminifera.

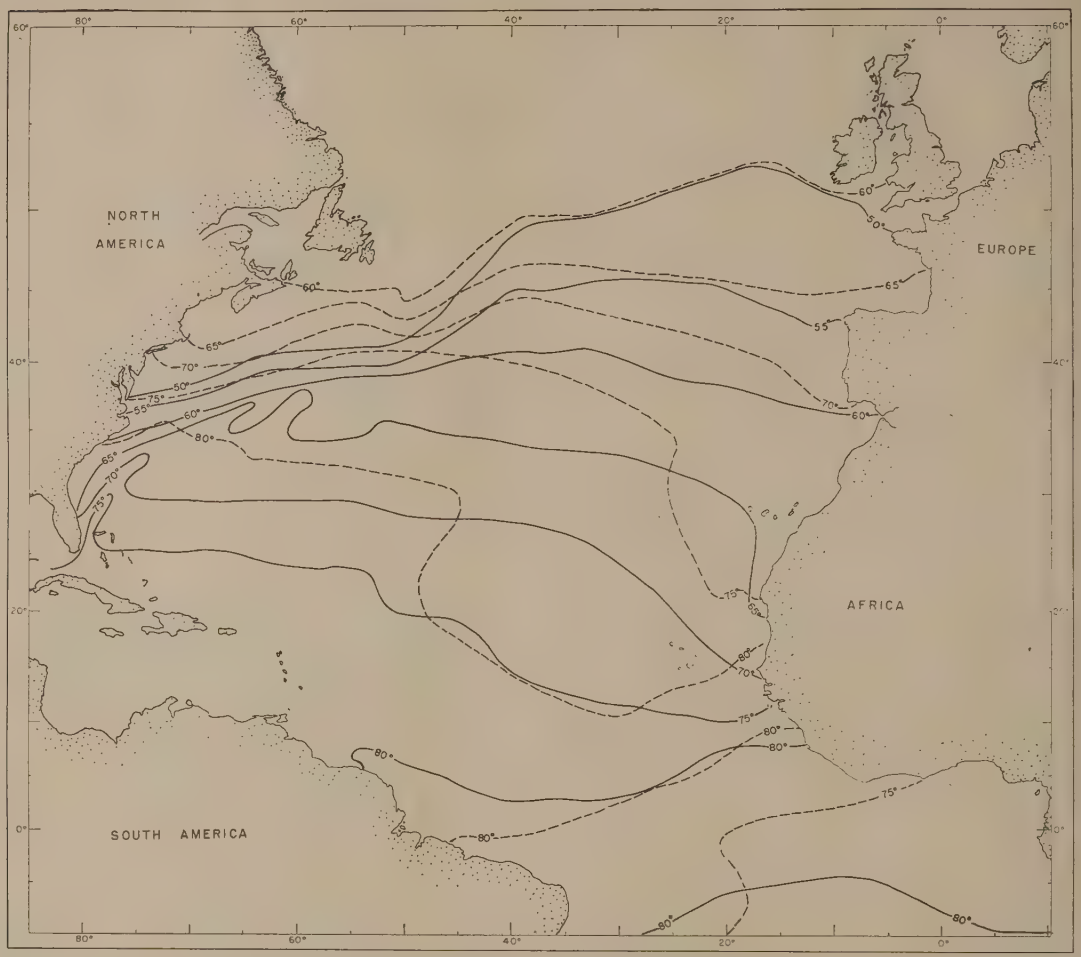

Fig. 21. Monthly mean sea surface temperatures; solid line: February; dashed line: August. (From U. S. Hydrographic Office *Atlas of Sea Surface Temperatures*).

The correlation between the distributions of species of planktonic Foraminifera and the mean monthly surface isotherms is not good in the statistical sense. It is sufficiently indicative, however, to suggest that the surface temperatures are of importance in the ecology of these species. The presence of typical low-latitude species in low frequencies in the northern part of the area covered is believed to result from the circulation pattern in the North Atlantic. It seems probable that these low-latitude specimens are carried into mid-latitudes by the tropical water masses invading those areas through the Gulf Stream system. These tropical species appear to have crossed the mean isotherms which normally constitute their northern boundary and are now deposited in a foreign latitude.

The faunal compositions of the samples in the eastern Atlantic between Cape Verde and Cape Blanco approximately 15° to 20° N. Lat. are unusual in the present suite of samples. These faunas are mixtures of many of the low-latitude and high-latitude species both of which may occur there in frequencies similar to their more usual habitat. *Globorotalia menardii* and *Globigerina eggeri* which are characteristic of low latitudes in high fre-

quencies occur in this area in similar frequencies; *Globigerina inflata* and *G. bulloides* are characteristic mid-latitude species which are abundant in the area. The total apparent effect of these distributions is a southward displacement of the southern boundaries of some mid-latitude species and a northward displacement of the northern boundary of the southern species in this area. Similar »faunal mixing» is not suggested in these latitudes on the western side of the North Atlantic, although the populations at the few stations located there are too sparse for reliable results.

These faunas suggest that the environment in the area between Cape Verde and Cape Blanco is quite variable over relatively short periods of time. It appears that unmixed masses of both mid-latitude and low-latitude water invade this area at relatively frequent intervals and deposit their characteristic assemblages of planktonic Foraminifera, while there is no suggestion of a similar mixing in these latitudes on the western side of the basin. The following possible explanation for this has been suggested by Munk (personal communication). This area is in the North Equatorial Current where there is a convergence of Equatorial Counter Current water and mid-latitude water being brought in from the Canaries Current. These different water masses undoubtedly carry distinctive faunas which are thus deposited in the form of a »mixed» assemblage. As the Equatorial Current flows to the west these water masses are thoroughly mixed. No similar faunal mixing is to be expected on the western end of this current where there is a divergence of the equatorial water. Mixing of planktonic faunas undoubtedly is characteristic of oceanic areas where there is convergence of water masses; a similar »mixing» of faunas has been recorded from the area of the sub-Arctic convergence by Phleger and Hamilton (1946).

These considerations, together with the five generalized distribution types listed above, demonstrate the complex distributions of these assemblages. The ecologic factors causing these distributions are complex and very imperfectly known. In the following section the core faunas are interpreted in terms of possible sea surface temperatures which may have conditioned their occurrence. It is clear that these interpretations are tentative and are not based entirely upon presence and/or absence of any species but are based upon a series of complex relationships.

Distribution of Foraminifera in the Cores

Most of the samples in the cores were spaced 10 cm. apart, and consisted of a half section of the wet core 5 mm. in thickness. Each sample is thus taken to represent approximately 10 cm. of sediment, and the exact boundaries of faunal differences were not located precisely.

The core faunas are listed in Tables 2 to 37 in percent of total planktonic and benthonic populations. A brief description and discussion of the major faunal features of each core is given below. Interpretations of chronology are in part based upon information on the known distribution of planktonic species from data presented in the present paper and from other studies, indicated above. Further bases for the chronology are the imperfectly known ranges of a few fossil planktonic forms and inferred possible ranges of one or two additional modern species. Interpretations of displaced assemblages are based upon known depth ranges of some of the benthonic species in addition to associations of certain species with faunas containing the species of known relatively shallow-water distribution.

Description of Core Faunas

Core 215. The upper fauna appears to be essentially a modern one and extends through sample 2 at 10 cm. Sample 3 at 19.5—20 cm.

TABLE 2. Occurrences of Foraminifera in selected samples from Core 215 in percent of total population. Planktonic and benthonic populations computed separately.

CORE 215 DEPTH - 4,320 M.																													
SAMPLE	1	3	6	8	13	18	23	28	30	32	33	38	43	46	48	50	54	57	59	61	63	65	67	69	71	73	75	77	79
CM. FROM TOP OF CORE	1-1.5	14.5-20	44.5-50	69.5-70	115.5-120	165.5-170	214.5-220	264.5-270	285.5-290	305.5-310	315.5-320	365.5-370	415.5-420	445.5-450	463.5-470	488.5-490	523.5-530	538.5-540	569.5-570	619.5-620	669.5-670	719.5-720	769.5-770	819.5-820	869.5-870	919.5-920	969.5-970	1019.5-1020	1069.5-1070	1119.5-1120
PLANKTONIC POPULATION	6,200	14,200	19,500	49,300	95,600	95,600	39,800	157,000	64,800	39,300	52,400	21,000	32,000	25,200	46,700	25,900	38,100	54,400	39,300	39,300	39,300	39,300	39,300	39,300	39,300	39,300	39,300	39,300	39,300
Globigerina bulloides	23	33	32	42	33	20	25	26	18	21	21	27	19	24	2	8	3	2	2	2	2	2	2	2	2	2	2	2	2
G. digitata	.3			3					3																				
G. eggeri	7	16	13	13	10	1	5	2	3	5	10	5	5	15	14	17	13	15	14	15	15	15	15	15	15	15	15	15	15
G. hexagona										3																			
G. inflata	14	18	20	21	20	25	26	22	20	22	24	18	21	16	24	21	28	26	27	27	27	27	27	27	27	27	27	27	27
G. pachyderma		2	6	2	3	3	2	.8	2	.8	3	6	8	3	8	7	6	7	7	7	7	7	7	7	7	7	7	7	7
G. quinqueloba	.6		.3			.3					4		.5	.4															
Globigerinella aequilateralis	2	3	1	1	1.5	.6	2	1.4		1.7	1		2				.3												
Globigerinita glutinata	6	2	2	3	10	6	5	10	7	9	3	7	9	6	2	3	1	1	1	1	1	1	1	1	1	1	1	1	1
Globigerinoides conglobata		.5	.3		2	2	2	.8	.8	1	.7	.3	2	2	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1
G. rubra	25	17	16	9	12	20	17	1	24	27	28	20	20	21	11	12	10	10	10	10	10	10	10	10	10	10	10	10	10
G. sacculifera	10	2	.7			.6	1	.4	6	4	3		.8	3	8	3	9	9	9	9	9	9	9	9	9	9	9	9	9
Globorotalia hirsuta	2	.5	.3	.8		.6	4	4	4	1	.7	4	4	.8	2	4	2	2	2	2	2	2	2	2	2	2	2	2	2
G. menardii - tumida group										3	.4			2	.3		.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3
G. punctulata			.3												1	1	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7
G. scitula	.3	.7	2		3	3	.6	.4	.8	.3		1	.5																
G. truncatulinoides	10	4	4	5	5	7	9	2	11	7	3	9	10	5	20	13	23	24	24	24	24	24	24	24	24	24	24	24	24
G. sp. 2															.3		.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7
Orbulina universa	2	1	.5	.3	.8	1	1	.8		1	3	2	1	2	2	.5	2	2	2	2	2	2	2	2	2	2	2	2	2
Pulleniatina obliquiloculata									3						.5	.5	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7
[Sphaeroidina bulloides]																													
Sphaeroidinella dehiscens																	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3
BENTHONIC POPULATION	175	140	70	70	75	75	90	90	80	80	80	40	75	10	450	450	2000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
Amphistegina lessonii																	4												
Anomalina sp										1					1														
Bolivina tortuosa		5								1																			
Bulimina alazanensis								2																					
B. mexicana														4	1		1												
Cassidulina crassa		8												2	2														
C. subglobosa		7			7		4	3	7		3	4		2	2	6	8	8	8	8	8	8	8	8	8	8	8	8	8
C. sp. 1														7	2	4	7	7	7	7	7	7	7	7	7	7	7	7	7
Cibicides lobatulus											3			43	35	14	34	34	34	34	34	34	34	34	34	34	34	34	34
C. refulgens																17	4	4	4	4	4	4	4	4	4	4	4	4	4
C. robertsonianus	8	3			3		2	7	5		6			1															
Discorbis mamilla														2		1													
D. williamsoni		3																											
D. obtuso														7	6	5													
Ehrenbergina undulata									1						1	2	3	3	3	3	3	3	3	3	3	3	3	3	3
Elphidium complanatum														4		3													
E. crispum															1	3	9	15	15	15	15	15	15	15	15	15	15	15	15
Eponides umbonatus and variants		10	13	10	16	33	8	5	1		6	25	12	1	1	6	4	4	4	4	4	4	4	4	4	4	4	4	4
Gyroidina lamarckiana								1		4	3																		
G. orbicularis							2		1																				
G. soldanii variant					3		1		1		6	4			3	1													
Haglundina elegans															1	5													
Eggerella bradyi	15	8	10	9	8		19	20	12	4	3	9		2	3		1	1	1	1	1	1	1	1	1	1	1	1	1
Laticarinina pauperata															1	1													
Miliolids															6														
Nonion barleeanum														3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
N. formosum		3	3	2			1	8	4	4		3				2													
N. germanicum														1		1	1	1	1	1	1	1	1	1	1	1	1	1	1
N. pompilioides		3	3	2	3		2					3		1		3													
Nummoloculina irregularis														2															
Osangularia cultur														1															
Planorbulina mediterranensis														1	1		1	1	1	1	1	1	1	1	1	1	1	1	1
Planulina ariminensis		3												1	2	7	4	4	4	4	4	4	4	4	4	4	4	4	4
P. wuellerstorfi	15	3	8	19	17	33	16	9	10	21	22	12	38	2	6	6	8	8	8	8	8	8	8	8	8	8	8	8	8
Epistominella exigua	8	5	18	15	13		8	10	18	14	20	13	38	2	1														
E. umbonifera	23	5	15	27	16		15	4	7	18	22	9	12	1	1														
Pullenia bulloides	8		13		10	33	5	3	6	11	3	4		2	2	1													
P. quinqueloba							1		1		1			1	1	1													
P. sp		3																											
Pyrgo murrhina	23		3	2	1		5	4	9	4	3	9		4															
Quinqueloculina venusta			8	6	3		2	1			3	1																	
Q. cf. weaveri			3				1		1	1																			
Robulus										4							1												
Sigmoilina tenuis										4																			
Siphotextularia rolshauseni		3		2						4		1																	
Uvigerina auberiana and variant														3															
U. hollicki								23	9					1	5		5	5	5	5	5	5	5	5	5	5	5	5	5
U. hollicki																													
Valvulineria humilis		28	3	7	3		6																						
Virgulina bradyi									1					1															
V. complanata		3	3						1																				

contains displaced material evidenced by the presence of *Bolivina tortuosa* and *Discorbis williamsoni*. These species are generally of shallow water origin, from depths less than about 200 m., and it appears that the sediment has originated at these depths. *Planulina ariminensis* in this sample occurs in the Gulf of Mexico at depths less than 500 m. An examination of the core shows a series of layers of fine sand in the upper 42 cm. It seems possible that these upper layers are entirely displaced, although there is no additional faunal evidence for this. From 49.5 cm. through 220 cm. the planktonic fauna may be characteristic of a more northern assemblage as shown by the following: a decrease in frequency of *Globigerinoides sacculifera* and an increase of *Globigerina bulloides* in sample 8, a decrease in *Globorotalia truncatulinoides* and a decrease in *Globigerina eggeri* in the lower part of this section. Sample 30 at 289.5—290 cm. probably is a displaced fauna, as shown by the presence of *Bolivina tortuosa*. Another displaced fauna is suggested questionably in sample 33 at 319.5—320 cm. by the presence of *Cibicides lobatulus*, and it is possible that the displaced layer occurs between 289.5 and about 360 cm. From 369.5 to 420 cm. the planktonic fauna appears to be normal for the latitude. The faunas from 449.5 cm. to the bottom of the core at 539 cm. are clearly displaced from shallow water, as shown by the presence of the relatively shallow-water benthonic species: *Amphistegina lessoni*, *Bulimina mexicana*, *Cassidulina sp.* 1, *Cibicides* cf. *refulgens*, *Discorbis mamilla*, *D. obtusa*, *Elphidium complanatum*, *E. crispum*, *Nummoloculina irregularis* and *Planorbulina mediterranensis*.

Core 217. Visual examination of this core shows several thin sand partings. Sample 17 at 159.5—160 cm. contains one specimen of *Bulimina aculeata* and sample 77 at 759.5—760 cm. contains one specimen of *Bolivina pseudoplicata*. These two species are questionably indicative of water shoaler than the postion of this core. It is suggested that the sands and isolated occurences of these two species probably represent small terminal ends

TABLE 3. Occurrences of Foraminifera in selected samples from Core 217 in percent of total population. Planktonic and benthonic populations computed separately.

| CORE 217 | DEPTH - 4,360 M. | | |

259.5—260 cm. where another colder water assemblage is suggested by the absence of the warm-water species and the presence of *Globigerina pachyderma*; an increase of *G. eggeri* in this fauna cannot be explained. At 319.5—320 cm. the presence of *Globorotalia menardii-tumida* indicates slightly warmer conditions, and at 329.5—330 cm. typical mid-latitude conditions are indicated which continue to 459.5—460 cm., with slight variations.

Presence of *Globigerina pachyderma* at 469.5—470 cm. and absence of *Globorotalia menardii-tumida* suggest colder conditions extending to approximately 500 cm. The mid-latitude fauna appears at 519.5—520 cm. There are three additional, lower apparent shifts to colder water assemblages, at 619.5—620 cm., 649.5—650 cm., and 740—780 cm. The bottom fauna at 789.5—790 cm. suggests a possible trend to warmer water by the presence of *Globorotalia menardii-tumida* and the relative abundance of *G. truncatulinoides*.

Core 221. This core contains a mixed benthonic fauna of shallow- and deep-water species in most of the samples. The shallow-water species which are clearly displaced from shoaler water are as follows:

Anomalina balthica
Bolivina pseudoplicata
B. subaenariensis
B. sp. 1
Bulimina exilis
B. marginata
B. mexicana
B. aff. *subacuminata*
Cancris cf. *oblonga*
Cassidulinoides mexicana
Discorbis mamilla
Elphidium advenum
E. complanatum
E. crispum
Nonion asterizans
Planorbulina mediterranensis
»*Rotalia*» *beccarii* variants
Uvigerina senticosa
Virgulina mexicana

The following species are probably displaced, but are somewhat questionable:

Bulimina aculeata
Cibicides lobatulus
Discorbis williamsoni
Rotamorphina laevigata

Some of these shallow-water species appear to be restricted normally to a depth less than approximately 100 m. This suggests that the sediment in which they are enclosed moved downslope from a depth not greater than approximately 100 m. Since they are mixed with typical deep-water benthonic species, they must have been deposited at the approximate depth where they now occur. The sediment containing this mixed fauna also contains abundant sand in the majority of samples and numerous shell fragments in many samples. Examination of the core shows that the top section is very sandy to 115.5 cm. Below that depth there are numerous sand partings and »lenses» of sand. At 535 cm. an almost pure quartz sand occurs and extends to the bottom of the core. All the samples examined for Foraminifera contained some to abundant sand. Many of the quartz grains were larger than 1 mm. in diameter and some were well-rounded and frosted. This suggests that the sediment originated at or near the turbulent surf zone.

A few of the samples in this core did not contain any shallow-water benthonic species, and in some other samples these species were rare, as in samples 13—17 and 43—47. These samples all contain several quartz grains and it is believed that they represent displaced material. The occurrence of occasional specimens of shallow-water species in some of these samples suggests that they would have been found in all samples in the mid-section if sufficient material were examined.

Core 221 is interpreted as containing two

TABLE 4. Occurrences of Foraminifera in selected samples from Core 221 in percent of total population. Planktonic and benthonic populations computed separately.

CORE 221	DEPTH-4,940M.																														
SAMPLE	1	2	6	7	8	9	10	13	18	23	28	33	38	43	48	53	54	55	56	57
CM. FROM TOP OF CORE	1.5-2	9.5-10	49.5-50	59.5-60	69.5-70	79.5-80	89.5-90	119.5-120	169.5-170	219.5-220	269.5-270	319.5-320	369.5-370	419.5-420	469.5-470	519.5-520	529.5-530	539.5-540	549.5-550	559.5-560
PLANKTONIC POPULATION	31 700	27 700	14 500	11 000	4 450	6 500	16 000	28 000	63 500	25 700	51 000	54 000	36 000	25 500	26 500	3 950	7 900	2 500
Globigerina bulloides	19	3	16	16	23	41	5	5	5	1	4	3	3	5	5	27	67	47
G. digitata		2	3																	
G. eggeri	18	4	8	12	12	13	9	15	13	6	8	11	9	12	5	23	2	29
G. hexagona						3	1	3				1	3	1	1	2		
G. inflata	25	14	20	20	33	21	24	10	8	14	15	14	23	14	18	17	3	
G. pachyderma	5	.8	2	5		3	3						8		5	4	1	7
G. quinqueloba		.2		4		3		.7									.7	1	1
Globigerinella aequilateralis		2	2	2		1	3	1	1	.7	2	1	1	3	1	1	4	
Globigerinita glutinata	2	1	2	7	2	2	1	2	5		2	2	5	4	9	6	2	3
Globigerinoides conglobata	3	5	3	2			.6	2		.4	5	1	.8	.8	5	4	R	
G. rubra	12	18	9	7	9	6	3	1	7	30	17	25	19	20	21	11	10	9	10
G. sacculifera	12	36	17	7	8	5	15	21	16	19	19	22	16	21	19	3	3	1
Globorotalia hirsuta		.2	.5		2		.6		.6	1	.5	.2	.5	.5		.7	R	
G. menardii	1	10	→															
G. menardii-tumida group			.5		1	.3	4	13	10	20	11	9	9	9	9	1	R	
G. punctulata		.2					.3	1	3	2	1	3	2	1	.5	.7	R	
G. scitula	.3																	.6
G. truncatulinoides	.8	7	19	18	3	3	6	9	8	17	5	8	7	8	10	3	.5	2
G. tumida	.3	3	→															
Orbulina universa	.5	1	4	8	5	.3		1	.6	2	3	1	.3	.3	2	1	6	
Pulleniatina obliquiloculata	.3	.2	.3				.6	3	.3	1	1	2	.3	1	.5			
(Sphaeroidina bulloides)									3									
BENTHONIC POPULATION	650	60	100	40	300	250	25	25	20	50	50	50	50	25	25	25	100	50
Anomalina balthica	2	2				1	2											
Bolivina pettersoni	1	12	15	8	7	13	5	4	8	6	10	3	6	2	8	4	22	50
B. pseudoplicata	.2		1		1	1												
B. pseudopunctata						1												
B. sp. 1	1		1		.7	1	2											
B. subaenariensis	1		2			1	2										.8	
Bulimina aculeata	2						.8										.1	
B. exilis			1			1										2	3	2
B. marginata variant					1												2	
B. mexicana	.5																	
B. aff. subacuminata																	.7	
Cancris cf. oblonga																	.4	
Cassidulina carinata	4		4	3	4	3	8									3	2	6
C. crassa							.8										.2	
C. subglobosa	.6	5				2					3							
Cassidulinoides mexicana																	2	
Chilostomella oolina			1			1												
Cibicides lobatulus	15			3	9	5	14									16	4	26
C. sp.																	.8	
C. robertsonianus	.3	2	3	3		2		4	12	13	3	10	8	4	4			
Cibicidina rhodiensis	.6																.4	
Discorbis mamilla	1				2	2	4										.2	2
D. williamsoni	1	2			2	1	2									2	5	2
Elphidium advenum	17	3	7	3	23	13	24				7		2				6	7	20
E. complanatum	17	3	2	3	21	8	23				2				2		18	8	14
E. crispum	5			3	6	2	4		4								5		2
Eponides tumidulus											3					4		
E. umbonatus and variants	1	7	11	11	.7	6	8	8	6	10	5	6	11	8	9	2	3	
Globobulimina cf. turgida						3											2	2
Gyroidina lamarckiana		7	5	8						6		3	4					.3
G. orbicularis												2						
G. soldanii variant				3								10		4	6	4		
Eggerella bradyi	3	.5				1		16				3	3	6	7	4	8		.3
Nonion asterizans	1				2		.8								2		3	4
N. barleeanum	1					2												1	2
N. formosum			1								3	3	4	4	4	8		
N. pompilioides	.8				.7	1	.8	8	4		7	10	6	4	2	8	2	.7
Nummoloculina irregularis																		.1
Osangularia cultur						1												
Patellina corrugata					.7													
Planorbulina mediterranensis	8	2	1	3	4	4										2	11	12
Planulina wuellerstorfi	3	13	1	8	.7	4	2		4	6	7	13	8	9	2	4	2	4
Plectina apicularis		3																
Epistominella exigua	3		2	3		4	2	4	4		10	2		2	10	4		1	2
E. umbonifera	3	23	23	24	.7	6		16	12	19	10	11	17	11	29	31		.1
Pullenia bulloides	.5	7	4	5		3	.8	4	12	6	7	13	6	20	16	12		.7	2
P. quinqueloba			1		.7	1		4		3		2		4				.5	
P. sp.			2	3				8		3					4			.2	
Pyrgo murrhina	5	2	2		1	2		12	4			3	6	11	4			2	
P. oblonga	.3							8	4				4	2					
Ratamorphina laevigata			1								2							.1	
Quinqueloculina venusta											2	6							
Q. cf. weaveri	.8							12	8					2					
Robertina bradyi																		.2	
"Rotalia" beccarii variant	5				.7		4			6			2			5			
"R." beccarii sobrina	2				.7													4	
Sigmoilina schlumbergeri	2																		
S. tenuis	.2									6				2					
Siphotextularia curta														2					
S. rolshauseni			1					4	4	6	7		2				3		
Uvigerina hollicki				3	1	5	8			6	3	2	2			4	2		
U. hollicki variant	4		1							13									
U. senticosa																	1		
Virgulina adveva																4		2	
V. bradyi	2	2			2		8										2	.7	
V. complanata	2																		
V. mexicana				5		1							4	2			1		
Miliolids	8				2											2	.3		

principal displacements from shoal water, one extending from somewhat deeper than the bottom of the core up to approximately 540 cm. beneath the surface and the bottom of the other at about 120 cm. The relative abundance of shoal-water specimens in these two sections of the core and the presence of sand both suggest this. The midsection, between about 120 cm. and 530 cm., is believed to represent the finer-sediment fraction from a turbidity current which deposited the lower material; or it may represent finer fraction from other, nearby turbidity currents.

Core 223. There is no faunal evidence that any of the sediment in this core has been displaced from a shoaler depth. It appears to be a relatively uniform, lime-rich sediment with a few sand particles. It is believed that this core may be useful for interpretation of chronology.

The upper fauna is a normal mid-latitude assemblage with some mixture of low-latitude species extending to 39.5—40 cm. At 49.5—50 cm. there is an absence of *Globorotalia menardii-tumida* which may indicate that a slight shift of low-latitude water masses carrying this population have shifted southward. Essentially the modern fauna is present from 69.5 cm. to 109.5 cm., and at 119.5—150 cm. there is an apparent change in the fauna suggesting slightly cooler-than-present surface temperatures. This is suggested by a lower frequency of *Globigerina inflata*, increased abundance of *G. bulloides*, absence of *Globorotalia menardii-tumida*, and generally lower percentage of *G. truncatulinoides*; *Globigerina pachyderma* also is present in numerous samples in this section. At 429.5—430 cm. the *Globorotalia menardii-tumida* group is present, there is a slight increase in frequency of *G. truncatulinoides*, *Pulleniatina obliquiloculata* is present in some samples, *Globigerina inflata* shows a slightly higher frequency trend and there is a higher frequency of *Globigerinoides sacculifera*. This

TABLE 5. Occurrences of Foraminifera in selected samples from Core 223 in percent of total population. Planktonic and benthonic populations computed separately.

CORE 223	DEPTH - 3,820 M.																													
SAMPLE	1	5	6	8	13	18	23	28	33	34	39	44	49	51	55	55	59	61	66	71	76	77	80	80	85	90	95	100	105	110
CM. FROM TOP OF CORE	3.5-4	39.5-40	49.5-50	69.5-70	119.5-120	179.5-180	219.5-220	279.5-280	329.5-330	379.5-380	429.5-430	479.5-480	499.5-500	529.5-530	539.5-540	559.5-560	579.5-580	599.5-600	649.5-650	699.5-700	749.5-750	769.5-770	779.5-780	799.5-800	849.5-850	899.5-900	949.5-950	999.5-1000	1049.5-1050	1099.5-1100
PLANKTONIC POPULATION	3,700	2,400	2,800	2,800	2,700	3,500	3,800	1,550	1,300	28,200	1,400	1,600	7,800	5,900	5,900	10,100	21,300	19,600	8,650	5,650	5,650	2,350	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300
Globigerina bulloides	14	37	38	47	44	51	48	36	29	39	33	45	31	24	31	34	34	24	18	25	24									
G. eggeri	21	18	23	30	30	22	17	35	46	18	19	14	26	28	11	29	25	39	44	31	50									
G. hexagona										1				2	3	1			2	8										
G. inflata	32	18	24	11	15	15	27	13	18	25	24	22	30	24	43	25	23	28	24	21	14									
G. pachyderma						2			5	2		3						3	2	1	8	1								
G. quinqueloba			7																											
G. sp. 1																			1											
G. sp. 2						2	6														2									
Globigerinella aequilateralis	7	1	5	5	2	5	5	2	5	2	2	1	4		1	3	1			5	7									
Globigerinita glutinata	2	1	1	5	2	5	5	8	2	7		3	4	1	2	1	1	1	6	5	7									
Globigerinoides conglobata		1									5				3															
G. rubra	13	10	4	5	4	5	2	6	3	8	14	7	5	8	5	6	9	4	5	6	3									
G. sacculifera	8	5	2	2	2	5	2	1	1	1	2	2	3	5	2	1	2			1	7									
Globorotalia hirsuta						2																								
G. menardii	4	→															→													
G. menardii–tumida group		1		4							1	2	4	2	1															
G. punctulata	7	1			2			3	5	1	5	3	4	1	6		7	4		3										
G. scitula	7	1	2	2	2	4	2	6	5	2				8	6	3	3		6	5										
G. truncatulinoides	3	3	2	1			3	3	7	7	1	2	4	8	6		3		6	12	3									
G. tumida	5	→																												
Orbulina universa	2	3	3	2	4	2	1	5	5	3	3	5	3	2	2	2	2	7	4	8	3									
Pulleniatina obliquiloculata	2													8																
BENTHONIC POPULATION	700	700	900	500	900	900	500	1250	800	700	1000	500	600	650	600	700	550	300	400	200	200	200	200	200	200	200	200	200	200	200
Anomalina sp.		1	1							1	1									1										
Bolivina pseudopunctata					3	1		2		4	1	3																		
Bulimina aculeata																			1											
B. alazanensis		1																												
Cassidulina carinata			1																	1										
C. subglobosa		2	2		1		2	8		6		1	4																	
Chilostomella oolina			2																											
Cibicides robertsonianus	18	1	9		5	1	6		8	2	1	6	3	24	9	5	5	1	9											
C. sp.		6	8			1	7	2		2	4				2					3										
Ehrenbergina undulata					1	1				8																				
Eponides polius																		2												
E. umbonatus	14	1	3	10	8	4	5	8	10	7	4	3	9	12	5	3	5	8	4	7	4									
Globobulimina cf. turgida															2															
Gyroidina lamarckiana					1		2		8	2	1	3	1	4		1	2		2	7										
G. orbicularis	4													2	2															
G. soldanii variant		3	10	4		4	1	2	2	2	2	1	1		5	3	4	7												
Höglundina elegans	6	20	8	2					8					2																
Eggerella bradyi			1	12	4	12		6	8	10	2	3			5	5	1	1	5											
Lagenina pauperata		3	3																											
Nonion barleeanum									8	1	3	4			9		2													
N. formosum							2	2		2									4		4									
N. germanicum	3	6	1	2	1				3	8																				
N. pompilioides			1	2	7	9	7	4	8	7	4		7		11	5	6	6	5		4									
Patellina corrugata			1																											
Planulina wuellerstorfi	21	22	14	8	6	14	22	19	10	11	12	13	9	22	9	12	9	6	15	24	27									
Epistominella exigua	18	7	14	37	25	12	10	17	16	20	16	26	14	8	18	20	38	29	31	21	22									
E. umbonifera	7	8			1	7	15	2	4	3	2	6	5	2				1	7	10	4									
Pullenia bulloides			2	8	6	1	1	6	7	6	6	3	1	2		6	4	6		7										
P. quinqueloba	3	3	1			7			2	2		3	1	4			1	3	2		14									
P. sp.						3			8		1	4	4		2		2													
Pyrgo murrhina	3	7	8	2	14	9	14	10	6	7	20	7	6	6	2	3	6		11	10	4									
P. oblonga						3		2		3		1		2	2	1														
Quinqueloculina venusta	3	3		4	5		2	4	8	4	1		2	2			5			3	4									
Q. cf. weaveri		1	7				2	2	8						4	1		2												
Robertina bradyi	1		1																											
Sigmoilina schlumbergeri														2	2															
S. tenuis									2																					
Siphotextularia rolshauseni		3	1		1	3		2	8	8					2	1			7											
Spiroloculina sp.				2								1																		
Uvigerina hollicki					9	1		6	30	8	10	10	33		11	32	5	28	2		4									
Virgulina advena	1					3	1		8										2											
V. bradyi		1	1				1	2				1			2															
V. complanata		1			1			2		2			1																	

assemblage is similar to the modern one and extends to about 590 cm. Below that depth the fauna seems to represent considerably cooler surface conditions as suggested by the relative abundance of *Globigerina pachyderma* and decrease or absence of usual low-latitude species. Near the bottom of the core the relative abundance of *Globorotalia truncatulinoides* suggests a swing to somewhat warmer conditions.

Globigerina hexagona is present in low frequencies in a few samples below 379.5 cm. Typical *Globorotalia tumida* does not extend below 40 cm., and typical *G. menardii* extends, in a few samples as deep as 580 cm.

Core 228. This core contains numerous layers of fine, clean sand and a mixture of sand and mud elsewhere. The upper 25 cm. is essentially pure sand. The lowermost sections appear to contain little sand.

A displaced benthonic fauna occurs in the upper 35 cm. of the core, as shown by the presence of the following benthonic species whose normal habitat is at much shoaler depths:

Bolivina pseudoplicata
Bulimina marginata
Cancris cf. *oblonga*
Cibicides lobatulus
Cornuspira planorbis
Discorbis mamilla
D. williamsoni
Planorbulina mediterranensis
Rectuvigerina sp.
»*Rotalia*» *translucens*

The following shallower-water benthonic species occur from 149.5—160 cm.:

Anomalina balthica
Cancris cf. *oblonga*
Cornuspira planorbis
Discorbis williamsoni
Elphidium advenum
Planorbulina mediterranensis
Rectuvigerina sp.

At 229—229.5 cm. *Discorbis williamsoni* is present.

It appears probable that most of the material in this core has been displaced from a shoaler depth, much of it probably from the continental shelf. The lowermost section may be an ex-

TABLE 6. Occurrences of Foraminifera in selected samples from Core 228 in percent of total population. Planktonic and benthonic populations computed separately.

CORE 228	DEPTH-4,280 M.														
SAMPLE	1	3	4	5	10	11	14	17	24	27	32	34	42		
CM. FROM TOP OF CORE	9.5-10	29.5-30	34.5-35	39.5-40	89.5-90	129.5-130	149.5-150	159.5-160	229-229.5	259.5-260	309.5-310	349.5-350	409-409.5		
PLANKTONIC POPULATION	2,700	16,900	4,100	2,700	8,300	6,150	6,600	1,800	1,150	3,300	3,400	1,000	880		
Candeina nitida		.4													
Globigerina bulloides	50	11	47	16	18	22	38	21	21	20	21	16	22		
G. digitata		1				.4		.5							
G. eggeri	5	16	21	38	45	23	10	22	30	39	41	46	32		
G. hexagona	1		.4				.5						3		
G. inflata	2	3	4	10	12	16	3	21	19	22	18	19	14		
G. pachyderma					3	.5	.4		1	2	2	1			
G. quinqueloba	1														
Globigerinella aequilateralis		3	.4	1		3	2	2	.3	.5			1		
Globigerinita glutinata	17	1	5		2	4	9	2	3	.5			1		
Globigerinoides conglobata		.4						.4			.5	.4			
G. rubra	8	36	12	14	11	13	13	14	15	9	11	9	18		
G. sacculifera	1	12	4	11	5	7		5	7	5	2	3	4		
Globorotalia menardii	1	1	8				.5								
G. tumida		2													
G. punctulata		1	.8	4	.8	2		.4	.3	1	.8	.8	1		
G. scitula	10	.8	3		1	4	21	2	1		.4	.8	4		
G. truncatulinoides		.8	.8	2		.5			1		1				
Orbulina universa	3	2		5	1	4	3	5	2	1	2	3			
Pulleniatina obliquiloculata		1		.6									R		
Sphaeroidinella dehiscens													R		
BENTHONIC POPULATION	150	75	40	60	60	50	140	40	7	50	55	50	12		
Anomalina baltisch							2								
Bolivina pseudoplicata			18												
B. pseudopunctata	1						2				2		8		
Bulimina alazanensis			2												
B. marginata variant	7														
Cancris cf. oblonga	2						2								
Cassidulina carinata			12				4						8		
C. crassa	4		8				4								
C. subglobosa		3	1								2	2			
Chilostomella oolina								18	2						
Cibicides lobatulus	7		3												
C. robertsonianus		5			4	4		16		4	2	4			
Cornuspira planorbis	1						2								
Discorbis mamilla			.11												
D. williamsoni	7	3	12					8		14					
Ehrenbergina undulata						2					2				
Elphidium advenum							2								
Eponides umbonatus and variants		9		5	11	15		15	24	8	11	10	25		
Glomospira charoides			1												
Gyroidina lamarckiana	1														
G. orbicularis		1													
G. soldanii variant		4	1	2				2		4					
Eggerella bradyi		3	2	4	2			2		4	2	2			
Laticarinina pauperata													8		
Nodosaria sps							3								
Nonion barleeanum													8		
N. farmosum		5		2	8	6		2		4					
N. germanicum		19	9	2	3			5		4	4	4	8		
N. pompilioides		3	2	15	3	9		8		10	13	12	8		
Patellina corrugata	1														
Planorbulina mediterranensis	4		1				2								
Planulina wuellerstorfi		5	1	18	6	9		5	29	17	14	6			
Epistominella exigua	4	7		9	16	13	6	8		2	7	23	17		
E. umbonifera		12	2	14	15	15		10	14	10	13	4			
Pullenia bulloides		7	2	16	8	6	2	8	14	13	20	6			
P. quinqueloba	5	5		4	3	9	4	2			4	2			
P. sp.	5	1		2	5	2	6								
Pyrgo murrhina				5	2	2		8		8		4			
P. oblonga					2										
Quinqueloculina venusta		3								4	2	2			
Q. cf. weaveri										2					
Rectuvigerina sp.	5						6	2							
Robulus		3			2						2				
"Rotalia" translucens			8												
Siphotextularia rolshauseni													8		
Spiroloculina sp.				2											
Spirophthalmidium acutimargo							2								
Tretomphalus atlanticus	43		2												
Uvigerina hollicki					2				2	4	8				
Virgulina advena	1					10	9	6	2		2				
V. complanata							4	2							

ception. No interpretation of chronology has been made of this core. It is suggested that more than one displacement may have deposited this material.

TABLE 7. Occurrences of Foraminifera in selected samples from Core 229 in percent of total population. Planktonic and benthonic populations computed separately.

| CORE 229 | DEPTH-4,810 M. | | | | | | | | | | | | | |

fauna is indicated by the abundance of *Globorotalia menardii-tumida*, and the lower frequencies of the mid-latitude species. Another section showing mid-latitude affinities occurs between 569.5 and 640 cm., with a tropical suite of species coming in at 649.5 cm. and extending to 990 cm. The bottom sample at 999.5—1,000 cm. has a high frequency of *Globigerina inflata*, *G. pachyderma*, and no *Globorotalia menardii-tumida*, and is of a mid-latitude type.

Most of the samples in this core show evidence of abundant solution of calcium carbonate as shown by the high percentage of broken shells. Samples in which there is relatively little broken shell are at 289.5—290 cm. and at 569.5—570 cm. The relative abundance of *Pulleniatina obliquiloculata* in sample 76 at 739.5—740 cm. appears to be due to the selective solution of other species which probably originally were present in great abundance.

Globigerina hexagona occurs only deeper than 191 cm. *Globorotalia tumida* is present only in the top sample at 1.5—2 cm. *G. menardii* is present to a depth of 990 cm.

Core 230. This core appears to be composed entirely of red clay and contains evidence of abundant solution of calcium carbonate. Solution effects are especially striking in the upper 10 or 11 meters of the core in which there are only a few specimens of Foraminifera in a few samples. One lower section of the core, between 1409.5 and 1,470 cm. has relatively little solution effect in most samples. The sample at 1,299.5—1,300 cm. showed somewhat less solution than most of the other samples. No reliable interpretation of the Foraminifera in the upper two—thirds of the core can be made because there is little record at all, and no continuous record.

At 5.5—6 cm. two specimens, *Globigerina bulloides* and one specimen of *Globorotalia scitula* were identified, and in addition there are a few juvenile specimens of *Globigerina*

TABLE 8. Occurrences of Foraminifera in selected samples from Core 230 in percent of total population. Planktonic and benthonic populations computed separately.

| CORE 230 | DEPTH-5,500M. | | |

of the high frequency of *Globigerina eggeri*, low frequency of *G. bulloides*, presence of *Globigerinoides sacculifera*, and reduction in frequency of *Globorotalia scitula*. The frequencies shown in this sample have a low reliability, however, because of the very small population. At 1,019.5—1,020 cm. the fauna appears to be a definitely low—latitude one. The general abundance of *Globorotalia menardii-tumida* group, of *Globigerina eggeri*, *Globigerinoides sacculifera*, and *Pulleniatina obliquiloculata* in the rest of the lower part of the core seems to show low-latitude conditions during the time when this material was deposited.

Core 232. This core is composed of red clay. A large percentage of the Foraminifera is broken. Two large populations of complete tests occur at 67.5—68 cm. and at 119.5—120 cm.

TABLE 9. Occurrences of Foraminifera in selected samples from Core 232 in percent of total population. Planktonic and benthonic populations computed separately.

CORE 232 DEPTH-4,975 M.							
SAMPLE	1	3	6	12	14	18	
CM FROM TOP OF CORE	5-55	12-12.5	67.5-68	99.5-100	119.5-120	159-159.5	
PLANKTONIC POPULATION	2,550	2,700	1,800	2,550	2,600	1,100	
Globigerina bulloides				20	3		P
G eggeri	P	28	39	14	41		A
G hexagona		6		5			
G inflata		3	1	17	2		P
G sp 2				1			
Globigerinella aequilateralis				2			
Globigerinita glutinata				6			
Globigerinoides conglobata			.7		1		
G rubra		2		19	6		P
G sacculifera		4	9	2	24		C
Globorotalia hirsuta			.7	3			
G menardii-tumida group		58			14		A
G punctulata	P	3	1				
G scitula				5			
G truncatulinoides	P			6			P
G. tumida							
Orbulina universa			.7	5	4		
Pulleniatina obliquiloculata		3	6		4		P
Sphaeroidinella dehiscens			.7		1		P
BENTHONIC POPULATION		400	400	400	200		
Cassidulina subglobosa			1	17	2		
Chilostomella oolina					.5		
Cibicides robertsonianus		6	3		2		
Eponides tumidulus		2					
E umbonatus and variants		14	6		8		P
Eggerella bradyi		3	2				
Nonion formosum	P	6	7		7		P
N pompilioides	P		3		4		P
Planulina wuellerstorfi	P	11	2	17	3		P
Epistominella exigua	P	24	24	11	23		
E umbonifera	P	15	38	17	30		P
Pullenia bulloides		6	7	17	16		
P quinqueloba	P	6	2		2		
P sp					.5		
Pyrgo murrhina	P		3		1		P
Quinqueloculina cf weaveri			1				
Siphotextularia rolshauseni			1				
Virgulina advena		2	1		1		
V complanata	P						

The undisturbed surface sample from the short core contains the normal low-latitude assemblage. The upper sample from the long core contains a fauna indentified from fragments which appears to be mid-latitude in affinities, and is therefore a previous cycle of deposition. At 12—12.5 cm. there is a low-latitude assemblage dominated by *Globorotalia menardii-tumida* and *Globigerina eggeri*, and also containing significant populations of *Pulleniatina obliquiloculata* and *Globigerinoides sacculifera*. At 67.5—68 cm. the fauna suggests somewhat cooler than low-latitude conditions. At 99.5—100 cm. the fauna contains an abundance of *Globigerina bulloides*, *G. eggeri*, *G. inflata*, *Globigerinoides rubra*, *Globorotalia scitula*, and *G. punctulata*, a typical mid-latitude assemblage. At 119.5—120 cm. there is another low-latitude fauna which continues to the bottom of the core at 159 cm.

Core 233. This core is composed entirely of mud with no apparent sand layers. The upper fauna is characteristic of the low-latitude assemblage. At 19.5—20 cm. there is an assemblage more mid-latitude in character. At 29.5—30 cm. there is a typical mid-latitude fauna extending to approximately 159 cm. At 168 cm. the fauna is interpreted as being slightly warmer, and at 220.5 cm. there is what appears to be a mid-latitude fauna. Between 230 and 280 cm. the fauna is intermediate in aspect, and from 290 to 370 cm. it appears to be typical low-latitude. There is a shift to a mid-latitude assemblage at 419.5 cm. and at 500 cm. the low-latitude fauna is present. A fauna of essentially low-latitude characteristics continues to the bottom of the core.

There is some indication of mixing of the planktonic fauna in samples at 390 cm. and at 930 cm., shown by relatively high percentages of *Globigerina inflata* along with high percentages of *G. eggeri* and the *Globorotalia menardii-tumida* group. Questionable evidence for depth displacement is seen at 1,150 and 1,250 cm. with the

TABLE 10. Occurrences of Foraminifera in selected samples from Core 233 in percent of total population. Planktonic and benthonic populations computed separately.

| CORE 233 | DEPTH - 4,125 M. | | |

TABLE 11. Occurrences of Foraminifera in selected samples from Core 234 in percent of total population. Planktonic and benthonic populations computed separately.

| CORE 234 DEPTH-3,577 M. | | |

TABLE 12. Occurrences of Foraminifera in selected samples from Core 235 in percent of total population. Planktonic and benthonic populations computed separately.

| CORE 235 | DEPTH - 4,560 M. | | |

TABLE 13. Occurrences of Foraminifera in selected samples from Core 236 in percent of total population. Planktonic and benthonic populations computed separately.

| CORE 236 | DEPTH-5,065 M. | | |

that the sporadic occurrence of the fossil specimens above this level is due to reworking.

There is neither faunal nor lithologic evidence for faunal displacement of sediment, and it is believed that the material represents more or less continuous deposition in the place where it was collected.

Core 235. It is suggested that the upper 640 cm. of this core contains an essentially uniform, low-latitude fauna. Small variations which occur are difficult or impossible to interpret. There are some layers where faunal mixing is apparent, as at 130 cm., at 190 cm., and at 980 cm. The section from 650 to 860 cm. appears to be mid-latitude in type with the absence of the *Globorotalia menardii-tumida* group but is low-latitude in other elements of the fauna. There is a low-latitude fauna from 870 to 920 cm., a somewhat intermediate fauna from 930 to 970 cm., a low-latitude assemblage from 980 to 1,160 cm., and an intermediate one from 1,170 cm. to the bottom of the core at 1,417.5 cm.

Globigerina hexagona occurs from 159 cm. to the bottom of the core. *Globorotalia tumida* is in the upper 159 cm. One specimen of *Globorotalia* sp. 2 occurs at 1,060 cm. *G. menardii* is present in the upper 1,200 cm. One specimen of *Cibicides lobatulus* at 750.5—751 cm. is very questionable evidence of faunal displacement; this core is composed of an apparently uniform mud and displacement is considered unlikely.

TABLE 14. Occurrences of Foraminifera in selected samples from Core 238 in percent of total population. Planktonic and benthonic populations computed separately.

CORE 238	DEPTH-7,315 M.																												
SAMPLE	42	45	48	51	54	58	64	71	74	83	86	90	103	108	113	120	121	124	140	145
CM. FROM TOP OF CORE	389.5-390	420-420.5	445.5-450	479.5-480	509.5-510	549.5-550	659.5-660	674.5-675	684.5-684.5	766.6-767.2	788.5-789.5	819-819.5	944.5-945.5	994.5-1000	1023.5-1030	1083.6-1084.2	1089.5-1090	1174-1174.5	1281.5-1285	1344.5-1350
PLANKTONIC POPULATION	23	230	370	310	490	2,000	40,300	1,100	2,750	2,100	275	100	3,250	2,500	1,000	340	420	180	150	
Globigerina altispira																	6			1
G. bulloides	17	10	2	7	8	10	4	11	7	6	24	19	26	10	11	22	6	12	18	23
G. eggeri	9	32	32	37	30	34	37	32	39	51	22	34	36	36	39	28	29	41	32	37
G. hexagona		1			8	1				1	2	4			3	4				
G inflata		5	3	3	1	1	6	3	3	2	4	2	4	3	2		3	3	1	
G pachyderma					4	7		6	1				1		1			7	6	
G quinqueloba					4	2														
G. venezuelana																		6		
Globigerinella aequilateralis		1							6				1		6			3	2	
Globigerinita glutinata	24	16	2	10	3	18	4	8	4	3	23	9	15	5	5	28	9	4	21	14
Globigerinoides conglobata		4	8	6	4		4		1						1	3				
G. rubra	24	16	13	14	17	16	10	27	4	14	18	22	10	23	22	15	15	20	18	16
G. sacculifera	13	3	11	9	13	4	11	9	17	9	3	5	3	10	8	1	6	10	1	3
Globorotalia hirsuta						5	4	6	4	3					1	4	6	5		
G. menardii-tumida group		5	8	7	7	3	14	2	4	3	8	1	1	2	3		8	1	1	2
G. multicamerata							R													
G. punctulata		1	4	3	5	3	4	3	6	1	4	4	1	3	3	2	6	3	1	1
G. scitula		1		3	4	1				2		2		2	6	2	1	1	1	
G. truncatulinoides	9	4	12	3	7	2	5	1	7	4	2			2	2	1	5	1	1	7
G. sp. 2		2	2	3	4	2		1	7			7		1	1		2	1	3	1
Orbulina universa		1	1					7						5	3		2			
Pulleniatina obliquiloculata		1	8	4	6	2	7	2	18	2		1		1	1		9	1		1
Sphaeroidinella dehiscens			5		4	2	2	3	1								3			
BENTHONIC POPULATION	0	4	4	5	11	7	12	500	4	36	7	2	0	7	16	11	5	6	3	0
Bolivina cf. minuta					14															
B. pseudopunctata				20						3										
Bulimina alazanensis				9			12					50								
Cassidulina subglobosa			50	20		29	42	25	50	14	14				38	9	40		33	
C. reflexa															6	9				
C sp. 2					9		8								6					
Cibicides robertsonianus					9	14			25	3					6					
C. sp.										3	14					18				
Ehrenbergina trigona			25							5										
Eponides umbonatus and variants		25					33			5					19	18		18	33	
Gyroidina orbicularis				40	9		8			3					6					
G. soldanii variant									25					14						
Eggerella bradyi		25													6					
Laticorinina pauperata						14														
Nodosaria sps																	9			
Nonion barleeanum					9									28						
N. germanicum										3	14	50			6	9				
N. pompilioides			25		9					5										
Osangularia cultur				20				12												
Planulina wuellerstorfi					28					5				28			20			
Epistominella exigua										3	14					18				
E. umbonifera								12		3								18		
Pullenia bulloides		25						25		14	14					9				
P. quinqueloba					9					3	14									
P. sp.										6										
Pyrgo murrhina														14						
P. oblonga										3										
P. sps.																	20			
Quinqueloculina cf. weaveri					9									14						
Sigmoilina schlumbergeri							8													
Siphotextularia rolshauseni		25														9			33	
Uvigerina hollicki						29		12		3					6					
Virgulina bradyi										14	14						20			
V complonata										3										

Core 236. The top sample contains the same low-latitude fauna as the surface sample from the same station and this fauna appears to continue to 30 cm. An intermediate fauna between 40 and 60 cm. is suggested by decrease in the *Globorotalia menardii-tumida* group. At 70 cm. *G. menardii-tumida* is absent and *Globigerina inflata* is at higher frequency. There appears to be a total of at least five shifts to essentially mid-latitude faunas in the upper seven meters of this core, separated from each other by low-latitude assemblages. Below seven meters there are at least three layers which are interpreted as mixed faunas. There is a relatively high frequency of *Globigerinoides sacculifera* in most of the faunas in this core interpreted as mid-latitude.

Globorotalia tumida extends to 120 cm. *Globigerina hexagona* occurs at 700 cm. and at 830 cm. This core appears to be composed of

TABLE 15. Occurrences of Foraminifera in selected samples from Core 242 in percent of total population. Planktonic and benthonic populations computed separately.

| CORE 242 | DEPTH-3,620 M. | | |

iloculata and one of *Globorotalia truncatulinoides* at 351 cm.

At 420 cm. *Globorotalia* sp. 2 is present and occurs in most of the lower samples. The presence of this species suggests that the material is fossil, probably late Miocene or perhaps a little younger. One specimen of *G. multicamerata* occurs at 660 cm. *Cassidulina reflexa* is present between 1030 and 1084 cm.

TABLE 16. Occurrences of Foraminifera in selected samples from Core 243 in percent of total population. Planktonic and benthonic populations computed separately.

| CORE 243 | DEPTH-3,740 M. | | |

TABLE 17. Occurrences of Foraminifera in selected samples from Core 246 in percent of total population. Planktonic and benthonic populations computed separately.

| CORE, 246 | DEPTH- 3,210 M. | | |

TABLE 18. Occurrences of Foraminifera in selected samples from Core 248 in percent of total population. Planktonic and benthonic populations computed separately.

| CORE 248 | DEPTH - 4,580M. | | |

TABLE 19. Occurrences of Foraminifera in selected samples from Core 252 in percent of total population. Planktonic and benthonic populations computed separately.

CORE 252 DEPTH-4,480 M.

| SAMPLE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 |
|---|---|---

the following benthonic species which are adapted to shallow water:

Amphistegina lessonii
Angulogerina selseyensis
Bolivina globulosa
B. paula
B. pseudoplicata
B. pulchella
B. subaenariensis
B. tortuosa
Cassidulinoides mexicana
Cibicides cf. *refulgens*
Cornuspira planorbis
Discorbis cf. *columbiensis*
Nonionella sloanii
Virgulina mexicana
V. tessellata

The following benthonic species probably are shoaler-water types:

Bolivina cf. *minuta*
Discorbis williamsoni
Ophthalmidium inconstans
Rotamorphina laevigata

Globorotalia tumida extends to 60 cm. *Globigerina hexagona* only occurs below 180 cm.

Core 252. The top fauna is not the same as the fauna in the surface sample from the same position, mainly in the lower frequencies of *Globorotalia tumida* and *Pulleniatina obliquiloculata*. There are numerous layers in this core which show evidence of intense solution, as evidenced by the very low populations in many samples. In addition, there are at least three rather thick layers containing a displaced fauna. Moreover, approximately 4 meters of core are missing in the material furnished the writers, between approximately 6 and 10 meters in the core. These facts greatly reduce the value of this core for any chronologic study and none is attempted.

TABLE 20. Occurrences of Foraminifera in selected samples from Core 254 in percent of total population. Planktonic and benthonic populations computed separately.

CORE 254 DEPTH - 4,337 M.									
SAMPLE	1	2	3	4	5	6	7	8	9
CM. FROM TOP OF CORE	0-1	9-10	49-50	79-80	89-90	114-120	134-140	144-150	149-150
PLANKTONIC POPULATION	1-200	400-500	1-450-500	1-450-500	1-450-500	850-1,000	50,000-100,000		
G. obigerina bulloides	.3	.4	1	.6		.6		.8	
G. digitata		.4	1	.6					
G. eggeri	7	25	18		36	3	69	2	11
G. hexagona		.4		1	.7			1	
G. inflata	.3						.5		
G. pachyderma			.4						
Globigerinella aequilateralis	1	.8		.6		1	.5	.5	
Globigerinita glutinata	4		.4	.6	.7	6		1	1
Globigerinoides conglobata		.8	2	6	1	4	1	.8	3
G. rubra	32	17	18	9		28	3	39	3
G. sacculifera	45	41	30	23	14	38	3	29	19
Globorotalia hirsuta		.4		.6					
G. menardii	.6								
G. menardii–tumida group	.3		3	26	6	10	6	12	26
G. punctulata		.8	2	2		1		.8	
G. truncatulinoides	3	11	4	3	5	8	16		5
G. tumida	2								
Orbulina universa	2		2	3	.7	.6		R	
Pulleniatina obliquiloculata	3	2	14	25	34	5	1	2	1
(Sphaeroidina bulloides)	.3						1		1
Sphaeroidinella dehiscens					2				2
BENTHONIC POPULATION	25	40	40	60	45	1-5	100		200
Cassidulina subglobosa							1	2	5
Chilostomella oolina							1		
Cibicides robertsonianus	4			2	2				5
Eponides tumidulus		3			2				
E. umbonatus and variants	17	6		10	9		1	4	
Gyroidina soldanii variant				2			1		
Eggerella bradyi	4	6	3	3	2		1		8
Nonion formosum		8	3						
N. pompilioides		3		2	5				5
Planulina wuellerstorfi	4	1	1	1	3		6	2	5
Epistominella exigua	9	8	3	26	23	13	16	1	
E. umbonifera	30	33	81	44	32	80	67	13	54
Pullenia bulloides	13	3		5	2		3		8
P. quinqueloba		8		2	1		1		
P. sp.	4	6			2	7			5
Pyrgo murrhina	4	6			5			1	5
Quinqueloculina venusta								1	
Siphotextularia rolshauseni	4				5			1	
Textularia australis				2			2	3	
Virgulina bradyi								72	

The following shoaler-water benthonic species occur in the displaced sections:

Amphistegina lessonii
Angulogerina selseyensis
Bolivina globulosa
B. paula
B. pseudoplicata
B. pulchella
B. subaenariensis
B. tortuosa
Bulimina exilis
B. marginata
B. mexicana
Cassidulina curvata
C. norcrossi australis
Cibicides cf. *refulgens*

TABLE 21. Occurrences of Foraminifera in selected samples from Core 255 in percent of total population. Planktonic and benthonic populations computed separately.

| CORE 255 | DEPTH - 4,490 M. | | |

TABLE 22. Occurrences of Foraminifera in selected samples from Core 257 in percent of total population. Planktonic and benthonic populations computed separately.

| CORE 257 | DEPTH - 4,470 M. | | |

TABLE 23. Occurrences of Foraminifera in selected samples from Core 258 in percent of total population. Planktonic and benthonic populations computed separately.

| CORE 258 | DEPTH - 4,554 M. | | |

faunas displaced from shallow water. At 399.5—410 cm. the following shallow-water benthonic species are present:

Bolivina subaenariensis
Bulimina marginata
Uvigerina sp. 1

At 549.5—560 cm. the following shallow-water benthonic species occur:

Bolivina subaenariensis
Bulimina marginata

The following shallow-water benthonic species occur from 797 cm. to the bottom of the core:

Bolivina subaenariensis
Bulimina exilis
B. marginata
»*Rotalia*» *beccarii*
Uvigerina sp. 1
U. sp. 2

Core 261. This short core, only 40 cm. long, seems to have a low-latitude fauna throughout. The fauna in the top sample is somewhat different fromt he surface sample collected from the same station. *Globorotalia tumida* is 38% of the surface sample and is not recorded in the core. *Globigerina eggeri* is 29% of the surface sample and does not occur in the core. The material collected at this station has had extensive solution, and this may account for the faunal irregularities.

Core 262. This core has had extensive solution of calcium carbonate and as a result most of the 130 samples examined either contain no Foraminifera or only a few fragments. Only three samples contained enough specimens for analysis and these faunas have been modified by solution. Sample 4 at 29.5—30 cm. contains what appears to be a mid-latitude fauna not characteristic for the latitude at which it was collected. Sample 6 at 49.5—50 cm. has a low-latitude assemblage, and the fauna in sample 130 at 1,279.5—1,280 cm. has a mid-latitude composition. *Globorotalia tumida* is not present. There is a displaced fauna at 1,279.5—1,280 cm., indicated by the presence of the following benthonic species:

Bolivina subaenariensis
Bulimina exilis
B. marginata
Uvigerina sp. 1

Core 263. This core has had intensive solution, and only five sample have sufficient specimens for analysis. The upper 40 cm. contains a typical low-latitude fauna. *Globorotalia tumida* occurs at high frequency in this layer and is not recorded lower in the core. Samples 97 and 98 at 939.5 to 950.5 cm. also

TABLE 24. Occurrences of Foraminifera in selected samples from Cores 261, 262 and 263 in percent of total population. Planktonic and benthonic populations computed separately.

CORE	261			262						263					
DEPTH-M.	5,128			5,480						5,320					
SAMPLE	1	5		4	6	130				1	5	97	98	111	
CM. FROM TOP OF CORE	0.5-1	39.5-40		29.5-30	49.5-50	1279.5-1280				1-1.5	399.5-400	939.5-940	950-950.5	1069.5-1070	
PLANKTONIC POPULATION	100	500		120	250	90				135	125		1,150	10	
Globigerina bulloides	2	1			8	13								17	20
G. digitata	1														
G. eggeri				36	18	3				31	26	A	39	70	
G. hexagona	16	2				1									
G. quinqueloba														7	
Globigerinella aequilateralis	2	8				1					2				
Globigerinita glutinata					21	13									
Globigerinoides conglobata	5	7		5	2					4	11	R	11		
G. rubra	21	10		3	13	47				4	10	R	5	10	
G. sacculifera	23	9		4	9	5				11	22		6		
Globorotalia hirsuta					4										
G. menardii											2				
G. menardii-tumida group	11	24			14	2						A	11		
G. punctulata	2	7		8						2	5	R	2		
G. scitula						13									
G. truncatulinoides	4	2		34	3	2				7	3		5		
G. tumida										28	10				
Orbulina universa	1	2		8						8			1		
Pulleniatina obliquiloculata	8	35		15	14					13	7	C	14		
Sphaeroidina bulloides				8											
Sphaeroidinella dehiscens	2	4		2	1					7	8	C	3		
BENTHONIC POPULATION	5	18		80	55	45				95	80		70	0	
Bolivina pseudopunctata						2									
B. subaenariensis						7									
B. spp.						2									
Bulimina exilis						5									
B. marginata variant						14									
Cassidulina carinata						16									
C. subglobosa		6		1											
Cibicides sp						2									
Eponides tumidulus											1				
E. umbonatus and variants		6			2	9				4	1		3		
Gyroidina soldanii variant		6		1							1				
Nonion pompilioides					2								1		
Nonionella atlantica						9									
Planulina wuellerstorfi		6		4						4	1		4		
Epistominella exigua		28			2	9				2	1		4		
E. umbonifera	80	50		86	82	2				81	90	A	81		
Pullenia bulloides				1	9					2	1		1		
P. quinqueloba				4	4	2				2	1		3		
P. sp						2				3	1		1		
Pyrgo murrhina						5				1					
Uvigerina sp 1						9									
Virgulina complanata						2									

TABLE 25. Occurrences of Foraminifera in selected samples from Core 267 in percent of total population. Planktonic and benthonic populations computed separately.

CORE 267	DEPTH - 2,105 M.																								
SAMPLE	1	5	10	15	21	24	30	31	36	38	44	50	55	56	63	68	77	82	85	88	92	97	102	106	112	116	120
CM. FROM TOP OF CORE	0-1	39.5-40	89.5-90	139.5-140	189.5-190	219.5-220	269.5-270	279.5-280	339.5-340	354.5-355	419.5-420	449.5-450	479.5-480	509.5-510	539.5-540	569.5-570	609.5-610	659.5-660	749.5-750	799.5-800	829.5-830	859.5-860	939.5-940	999.5-1000	1039.5-1040	1099.5-1100	1139.5-1140	1179.5-1180
PLANKTONIC POPULATION	35,100	26,400	13,900	14,900	34,200	58,100	11,800	13,900	21,700	14,800	8,000	11,900	16,800	13,100	11,200	11,200	12,500	26,800	17,200	17,900	17,900	33,200	54,400	16,300	9,900	7,800	21,500
Candeina nitida	3	1			.3																						
Globigerina altispira															3	4	3	2	4	.7	1	5		1			
G bulloides	8	.7	3	4	4	1	2	4	4	3	8	3	5	6	2	4	1	2	1	.7	1	1	3	3	4	1	4
G digitata				.4	.3		.2					.3															
G eggeri	2	6	6	9	8	20	19	.7	2	19	6	15	6	7	6	3	1	2	6	2	3	7	6	4	11	13	16
G hexagona					1	4	2	3	3		.8		1	1		1		.7							2		
G inflata																		.2	.4	2		1	.6		1		
G pachyderma						.2													.7	.7	3	2						
G quinqueloba								1																			
G venezuelana															1	.7	1	1	2	3	1	2					
Globigerinella aequilateralis	.7	3	2	3	2	3	2	5	3	5	6	2	6	5	.8	6	4	2	.7	2	2	2	1	3	1	.4	1
Globigerinita glutinata	4	5	6	6	6	1	5	4	2	3	5	4	4	5	3		6	3	7	7	3	1	1	.8	2	2	
Globigerinoides conglobata		.7	.5	1	2	2	.6	2	1	.3	.8	2	2	2	1	.7	1		.4			.4	.6		.6	3	.6
G rubra	56	49	50	43	48	52	45	50	48	43	46	49	61	52	55	60	63	65	65	61	67	55	61	65	52	52	54
G sacculifera	7	20	12	9	13	13	9	16	19	11	9	13	6	12	15	9	5	12	7	7	9	10	16	14	23	19	14
Globoratalia menardii	1	→																									→
G. menardii–tumida group	.7	2	13	14	10	1	9	9	8	9	8	6	4	3	6	6	6	2		.4		.8	1	4		.4	1
G punctulata	R		2	3	2	.7	.6	.7		.3	.4						3	2		.4		.2	.6	.4			
G scitula	.7	4	1	2	2	4	3	3	1	2	4	1	.3	2	2	2	.5	3	5	3	4	2	4	2	1	3	1
G truncatulinoides	R	2	2	.4	2	3	1	.5	5	2	2	4	2	4	4	2		2	.7	2	.4	5	2	.8	1	4	3
G tumida	.4	→																									
G. sp. 2			R						R	R											R		R		R		R
Orbulina universa	10	4		2	.3	2	1	2	.6	1	4	.3	1	.5	.4	2	5	2		1	.7	1		1	.3	1	.6
Pullenatina obliquiloculata		2	1	2	1	.7		2	6	.3	.8			.5	.8		.5	1		.4	2	2	1	2	.6		.3
Sphaeroidinella dehiscens		.2							.3					.5				.2		.4	.4	.2	.6				.3
BENTHONIC POPULATION	170	45	65	30	50	50	30	25	55	40	20	30	25	30	25	15	25	20	20	30	15	45	20	90	45	25	30
Amphistegina lessonii			1						2																		3
Angulogerina seiseyensis		2		3						2	4	3	7								6		10		4		7
Bolivina globulosa																					6						
B cf minuta	1	2	3	3	2		3			2	4			17	4					4	6	7		2			
B paula	7					2																	5	1			
B pulchella									2														10	1			
B pseudoplicata	10				2	2	3		2		4	3			4		4		9		23	2		2			3
Bulimina aculeata			3																								
B alazonensis	1																										
B mexicana											4											2					3
Cassidulina carinata													4									5					
C crassa					2	2	3			2																	
C subglobosa	7	16	1	6			3		3	2	9				4					4				1	4		
Chilostomella oolina																	4										
Cibicides kullenbergi	1	2	1		13		7	4		2														2		4	
C. cf refulgens																	4		5	4		16	5				
C robertsonianus	2	2	1	3	2				3																		
C sp.															4												
Cornuspira planorbis	1					2	3																				
Discorbis cf. columbiensis	1																4			4					2		7
D. williamsoni			14								4									7		2	14	3	2	4	
Ehrenbergina undulata	1				2								3														
Elphidium advenum	1																										
Eponides umbonatus and variants		2	3	3	2	2			2	5					9			5							7		3
Glomospira cf. gordialis	6	7					17	4																			
Gyroidina lamarckiana	2	2	3			2																					
G orbicularis	1									2																	
G soldanii variant					4																						
Hoglundina elegans		7	6		33	8			16		9	3	4	11		12	4			4		2		1			
Eggerella bradyi						4			2																2	4	3
Laticarinina pauperata				6			3			2												2				4	
Miliolids	6		1	6			3			5					9	18		10	5	13		7		1	4	4	
Nodosaria sps.																						2	5	50	20	8	7
Nonion formosum														4			4				6						
N. germanicum						2						3										5	5	1	2		
N. pompilioides				3		2			2	4											6				2		
Nonionella sloanii	1														6	4		5				2			7	4	
Nummoloculina irregularis	5	13	21	6	10	17	27	12	16	14	15	18	10	14	13	12	14		4	6	7	14	2	9			7
Ophthalmidium inconstans		2	23	3	2	10	10	14		17		11	7		9		16	5	5	7	17	2	5	1			
Osangularia aultur					2				5			4						5				2					
Patellina corrugata				3		2																					
Planulina wuellerstorfi	2	7	3	3	4	2		4	2	1	0		7	4	11								5	3			
Plectina apicularis		2																									
Pleurostomella acuminata															4										4		
Epistominella exigua				3																							
E umbonifera	7		1			4																					
Pullenia bulloides		2							2			4				4		4		4							
P quinqueloba	2																										
P cf. riveroi	5	2							2										5								3
Pyrgo murrhina	1	7	3	3	2					5		3	14			12		5						3		4	
P. oblonga														4		6											
Quinqueloculina venusta		2				2				2			4					10									
Q. cf. weaveri	2	4				6	6	3	12				7	4	14			5							2	4	
Robertina bradyi	5	4	4	6	8	8	3	4	14	12		22	4	4		6		19		4	6	5		4	9	8	3
Robulus																									2		
Rupertia stabilis																		4									
Sigmoilina schlumbergeri	1	4							2																		
Siphotextularia curta	1												4							4							
S rolshausen.	1					2		8					4											1			
Spirophthalmidium acutimargo				3						5	9							5							2		
Tretomphalus atlanticus	7	4	3			4	4		4	3	2	15	3	4	4	4	12	8		5		12	12		2	7	
Trochammina cf advena	7																										
Triloculina tricarinata			4	3		6	3	12		7			4	14		6	12	19			6	2		2	4		
Uvigerina auberiana and variant	2			25	2	10		18	2		4	3	14			12	16		42	38		14	24	12	2	52	41
Virgulina bradyi				3						15	11																
V. complanata													4														
Valvulineria araucana	2																										

appear to contain a tropical fauna. Sample 110 at 1,069.5—1,070 cm. appears to have a mid-latitude assemblage, but only ten specimens were seen.

Core 267. This core is white in color and appears to be essentially pure calcium carbonate. All samples contain high populations of Foraminifera and the material may be called a *Globigerina* ooze, with considerable solution having occurred. The material of this core appears to be essentially all displaced from shoaler water than the depth at which it was collected. Several of the following shallow-water benthonic species are recorded from all but three of the core samples:

Amphistegina lessonii
Angulogerina selseyensis
Bolivina globulosa
B. paula
B. pseudoplicata
B. pulchella
Bulimina mexicana
Cibicides cf. *refulgens*
Cornuspira planorbis
Discorbis cf. *columbiensis*
D. williamsoni
Elphidium advenum
Nonionella sloanii

Since most or all of this core has been displaced from shallow water, it appears undesirable to attempt a chronology based upon shift of the modern planktonic assemblage.

Three fossil species are present. *Globigerina altispira* and *G. venezuelana* occur in significant

TABLE 26. Occurrences of Foraminifera in selected samples from Core 276 in percent of total population. Planktonic and benthonic populations computed separately.

| CORE 276 | DEPTH - 4,852 M. | | |

frequencies from 610 cm. to at least 950 cm. *Globorotalia* sp. 2 occurs in a few samples from 90 cm. to the bottom of the core.

Core 276. This and the succeeding cores described here are from mid-latitude areas, 30° N Lat. to approximately 42° N Lat. The modern fauna is thus a mid-latitude assemblage; differences from this fauna and one representing areas of colder surface water are difficult to ascertain. In this core these differences appear to be indicated largely by variations in frequency of *Globigerina pachyderma* and *Globorotalia truncatulinoides*. Low percentages of typically low-latitude species such as *G. menardii*, *G. tumida*, and *Pulleniatina obliquiloculata* probably are to be expected in this area because of the water circulation pattern and generally are not considered indicators.

According to our interpretation there are at least four shifts from mid-latitude assemblages to assemblages which appear to represent somewhat higher-latitude conditions.

Core 278. The fauna in the upper 80 cm. of this core is so fragmented by intense solution that it was not counted. The uppermost sample studied, at 90 cm., contains a colder-than-modern fauna, and there are three additional colder-water assemblages, separated by the normal mid-latitude fauna, in the lower core sections. The indicative species for the modern, mid-latitude assemblage in this core appear to be *Globorotalia truncatulinoides*, *Pulleniatina obliquiloculata*, *Globorotalia menardii-tumida*, and *Globigerinoides conglobata*. Indicators for the colder assemblage appear to be relatively high frequencies of *Globigerina pachyderma* and *G. bulloides* together with low frequencies or absence of the mid-latitude indicators.

Core 279. The upper core fauna appears to represent somewhat colder surface water conditions than the surface sample collected at the same station. There appear to be nine shifts to colder-water faunas in the 19 m. length of this core. Criteria for differentiating the faunas are the same as described above.

Core 280. There are nine faunas in this core which are interpreted as representing somewhat cooler surface water conditions than the modern mid-latitude assemblage. This is based largely on the lower frequencies of *Globorotalia truncatulinoides* and increase of *Globigerina pachyderma*. The top sample of the core contains *Bolivina subaenariensis* and *Bulimina exilis*, both of which are shallow-water species. The cooler-than-present faunas are interbedded with warm-water faunas.

TABLE 27. Occurrences of Foraminifera in selected samples from Core 278 in percent of total population. Planktonic and benthonic populations computed separately.

CORE 278 DEPTH-5,520 M.														
SAMPLE	10	13	14	46	54	58	59	63	68	102	134	150
CM. FROM TOP OF CORE	89.5-90	119.5-120	129.5-130	449.5-450	529.5-530	569.5-570	579.5-580	614.5-620	869.5-870	1009.5-1010	1324.5-1330	1489.5-1490
PLANKTONIC POPULATION	540	10,000	5,000	550	1,000	1,200	1,750	1,200	800	2,050	500	2,860
Globigerina bulloides	35	23	3	5	10	6	41	8	10	10	2	11
G. digitata						1					.4	
G. eggeri	16	13	7	13	8	6	5	12	10	3	17	6
G. inflata	8	22	36	47	29	24	15	39	44	35	42	20
G. pachyderma	4	2		.2	1			1	.5	2	.4	.3
Globigerinella aequilateralis	.7	1	.6	2	2	2	2	2	.2	1	1	1
Globigerinita glutinata	.7	1		.4	1	.3	3		1	3	.8	2
Globigerinoides conglobata			2	.5		.3			1	.4		.8
G. rubra	23	24	5	14	34	24	25	31	15	22	21	29
G. sacculifera		3	1	11	6	1	1	2	2	6	2	4
Globorotalia hirsuta	1	2	5		1	2	.7		2	3	5	1
G. menardii-tumida group			.6							1	.8	.3
G. punctulata	.4	4	10	.2	.2	1	.2	.3	4	1		2
G. scitula	2	.5				.3	2					.3
G. truncatulinoides	2	3	24	5	6	13	4	3	10	11	5	31
Orbulina universa	1	2	.4	2	3	6	.7	2	.2	.6	2	2
Pulleniatina obliquiloculata			1			.3				.8		.3
Sphaeroidinella dehiscens			.3									
BENTHONIC POPULATION	355	4,000	600	15	15	30	25	30	25	50	30	40
Cassidulina subglobosa	6	7	5					10	8	9		10
Cibicides robertsonianus			2									3
Eponides tumidulus						7				2		
E. umbonatus and variants	11	14	25		23	14	8	3	17	13	23	18
Gyroidina orbicularis										2		
G. soldanii variant		.5	2									
Eggerella bradyi	3	6	3		6	14	8	43	21	2	10	3
Nonion pompilioides	3	5	9		6		4		17	2	10	
Planulina wuellerstorfi		3	14	40	18	14	8	13	13	2	6	8
Epistominella exigua	30	13	5		6				4	17	13	3
E. umbonifera	22	28	23		18	11	4	10	8	30	3	29
Pullenia bulloides	6	9	5							15		3
P. quinqueloba	20	6	2	60	23	25	38	17		2	16	16
P. sp.		4	2				8		4		6	
Pyrgo murrhina		4									3	
Quinqueloculina venusta						4						
Q. cf. weaveri			3							2		
Robulus						4		3			3	
Siphotextularia rolshauseni		.5					13		8	2	3	8
Textularia australis		.5	2									
Valvulineria humilis						7	13					
Virgulina bradyi		1									3	

TABLE 28. Occurrences of Foraminifera in selected samples from Core 279 in percent of total population. Planktonic and benthonic populations computed separately.

| CORE 279 | DEPTH - 4,663 M. | | |

TABLE 29. Occurrences of Foraminifera in selected samples from Core 280 in percent of total population. Planktonic and benthonic populations computed separately.

CORE 280 DEPTH - 4,256 M.

SAMPLE	1	4	10	14	18	22	25	29	33	35	37	41	44	47	51	54	58	62	64	70	73	76	79	82	87	90	95	98	101	104	107	110	115	118	121	124	129	133	136	140	142	147	150	154	156	162	164	169	174	178	183	187
CM. FROM TOP OF CORE	1-2	29.5-30	80.5-90	125.5-130	164.5-170	234.5-240	274.5-280	313.5-318	333.5-340	359.5-360	369.5-370	399.5-400	449.5-450	499.5-500	549.5-550	559.5-560	569.5-570	604.5-610	629.5-630	689.5-690	699.5-700	744.5-750	774.5-780	804.5-810	894.5-900	934.5-940	964.5-970	974.5-980	1013.5-1020	1023.5-1030	1043.5-1050	1083.5-1090	1093.5-1100	1139.5-1140	1159.5-1160	1169.5-1170	1179.5-1180	1229.5-1230	1279.5-1280	1319.5-1320	1349.5-1350	1389.5-1390	1409.5-1410	1459.5-1460	1489.5-1490	1539.5-1540	1549.5-1550	1559.5-1560	1609.5-1610	1659.5-1660	1674.5-1680	1744.5-1750	1794.5-1800	1839.5-1840
PLANKTONIC POPULATION	8,500	4,600	1,000	1,700	1,700	2,350	3,100	3,900	3,900	3,900	2,200	5,100	1,700	3,600	2,250	3,100	8,200	3,900	4,900	5,200	6,150	1,879	3,300	6,000	2,400	7,350	4,650	2,550	3,100	3,255	2,955	2,350	3,200	2,350	580	3,900	3,900	2,050	3,050	4,550	4,900	1,000	4,700	1,450	1,050	3,000	2,500	2,400	2,500	2,700	2,050	17,350	4,350
Candeina nitida																																					.2																	
Globigerina bulloides	20	22	15	15	20	32	36	39	38	43	43	8	24	7	31	21	18	29	18	19	24	18	18	6	12	13	22	17	26	24	20	17	15	16	15	21	16	3	25	17	24	14	13	21	13	5	22	11	3	18	21	13	6	15	5	27	22
G. digitata								4																																.3										.3					
G. eggeri	3	8	4	12	13	12	13	12	12	15	20	20	6	25	6	10	12	20	21	39	25	24	26	14	5	15	24	11	11	15	15	11	36	16	21	11	34	49	10	16	16	15	12	31	20	37	23	6	37	36	20	14	8	36	37	32	18	12
G. inflata	33	40	60	56	47	25	31	18	17	20	20	67	33	62	19	33	31	26	32	19	25	19	36	54	39	28	24	22	20	17	27	27	23	28	23	21	26	31	32	44	28	24	28	20	27	43	30	30	35	17	28	25	35	25	37	18	18
G. pachyderma	3	1	.8	.4	1	2	3	2	2	3	4	6	2	4	.6	1	4	3	2	4	4	2	2		.5	.4	.6	1	1	2	4	2	5	4	4	.7	3	2	.4	1	1	2	3	2	4	2		7	3	1	.8	1	5	5	1		2
G. quinqueloba									R															.3																																
Globigerinella aequilateralis	3	2	.4	1	.7	1	1		1	.6		.4		.8	.7	2	.5	.8	.4	.3	1	.5	.4	2	2	1	2	.7	2	.6	1	.3	.3	.3	1	1		2	.4	.5	.8	.8	1	.7	.3	.7		.4	1	1	3			3	.7
Globigerinita glutinata				.3				1	3	.6			2		2	.7	3	3		.6	.3	2	2	1	1	3	2	2	3	3	3	1	.3	1	1	2		1	.4	2	2	.5	.3			2		.4	3	.3	2		2	.8	1	2
Globigerinoides conglobata	R	.8		.3	.2	R	.3	R	.4	.3	.4		.3	.5	.8	2	.3	.3		.2	.7	.3	.8	.4	.5	.4	.8	.8	1			.3	.8	.3	.6	.5	R	2	.2	.4	.5	.8		.3		2	1		R	1	.3	.3	.8	R	.4
G. rubra	16	15	13	7	14	16	9	16	15	12	7	4	14	7	16	13	14	12	7	10	10	14	5	5	10	9	7	12	12	10	12	15	5	12	11	19	6	3	11	8	15	14	6	12	7	8	13	5	5	14	13	20	5	5	5	12	17
G. sacculifera	2	2	2	1	1	2	.8	.4	1	.6	.4		2		.6	1	3	1	2	.4	.3	.6	2	1	.4	2	1	3	5	2	.6	3	.8	2	1	1	.3	.7	2	.8	2	4	2	2	1	.7	5	.6	1	2	1	2	2	.6	1	2	3
Globorotalia hirsuta	6	1	.4			.3	3	.6	R	1	5	5	1	3	3	4	2	7	3	5	10	1	2	13	9	1	7	4	3	.6	6	.8	.6	4	3	.2	.3	.4	.1		3	.3	4	.3	.6	6	1	12	8	7	4	.3	.6	1		2
G. menardii	R																																																					
G. menardii – tumida group		R										R		R	.4	R				R	.3			.1	R	R	R	.3	R	.5	R	.6	1	.4	.7	.3	.4	.4		.4	.3	.7	.3	.3	1		.4	1	.6	1	.3		1	.4	2	.8
G. punctulata				R					.3			.3	.5	.6	2	1	.5		.2		2	.3	.4	2	3	.8	2	1	3	2	1	4	5	4	4	6	6	4	3	6	5	5	1	4	.7	1	2		.6	.3	.7	1	1	5	8	5
G. scitula	.2	.5		.6	R	6	2	.6	7	3	.4		.3		3	.2	1	2	.4		.3	1	2		.5	2	1	1	2	5	4	4	2	2	2	6	1	.3	1	2	1	2	1	1	1	1		.7		.4	3	2	3	.3	3	.4	1	5
G. truncatulinoides	9	4	4		2	2	2	2	3	2	2	.8	10	3	13	12	5	1	6	3	4	7	3	.6	8	11	6	15	10	10	10	9	4	9	9	6	2	1	8	9	6	14	7	8	4	9	6	5	5	11	12	8	4	1	9	6	10
Orbulina universa	3	3	.8	2	.5	1	1	.8	1	.6	.4		.3	.5	.8	1	3	.8	1	1	2	1	2	4	3	2	2	2	2	2	1	2	5	3	.8	2	3	1	2	2	1	2	3	2	1	2	1	.6	.4	.6	1	2	2	5		1	1
Pulleniatina obliquiloculata	.3											.3		.2		.3								3	.2		.4		R		.2		.2									R							.4		R
Sphaeroidinella dehiscens														.2										.5	.4		R																									
BENTHONIC POPULATION	650	450	350	250	550	750	1,050	400	450	400	350	350	450	400	450	500	400	450	600	450	650	700	750	780	800	810	880	880	940	970	1,020	1,050	1,050	1,090	1,100	1,140	1,160	1,170	1,180	1,230	1,280	1,320	1,350	1,390	1,410	1,460	1,490	1,540	1,550	1,560	1,610	1,660	1,680	1,750	1,800	1,840
Anomalina sp												1		.8																																									
Bolivina pseudopunctata						3							.8	.8																																								
B. subaenariensis	8																																																					
Bulimina aculeata																																						.7																
B. exilis	2																																																					
Cassidulina subglobosa	6	9	3	9	2	7	4	9	22	13	5	8	6	3	9	6	3	10	7	9	10	6	8	3	8	7	7	5	6	20	11	9	1	8	4	9	8	1	16	7	9	10	4	4	4	4	12	13	3	9	9	3	5	8	3	11	14
Chilostomella oolina	2								2	2													1																																			
Cibicides robertsonianus	2							3	2			6		4	4	1			3	1	2	3	1	3	3	3		.6		1	.8		1					1			3	1				1				3	1			2		
Ehrenbergina undulata																							1										1	1	2											1	.6								1
Eponides polius	5						2						.8																																									
E. pusillus			9		2												3						1	1																															
E. tumidulus								3			3																																												
E. umbonatus and variants	8	14	18	5	22	22	19	11	10	13	30	16	13	25	6	8	9	14	31	18	25	22	13	24	11	8	21	9	10	10	8	20	7	14	22	32	15	22	15	16	11	9	7	14	14	21	11	21	22	19	16		11	10	11	12	9
Gyroidina lamarckiana																																																						1
G. orbicularis																																						.7																
G. soldanii variant	2					6	4						2	.8		3		10						2	1		.6	.8		2		2		1	3		1	3	4		.6			1	2	1	4			2		1	.6
Eggerella bradyi		2		11	6	13		7	5		2	3	2	3	6	2	3	3		2		8		1	2	11	3		2			7	2	.7	3	6	3	2	2	7	4	4	5	5	1	7		3	8	6	3	4	7		5	2
Laticarinina pauperata		2																																																				
Nonion formosum							4	1	2	3		2		.8	.8	2				1					.8	3	1	3	.6		1	.8	2	.7				2	.7	3			1		1			.4	1	1		1	2		1	
N. pompilioides	3	2	9	5		2		2	8	4		3	5	10	2	4	4	7	24	18	4	6	3	5	2	2			2	2	2	2	.7	1			1	1			1	1	4	2	5	.8		3	5	1		2	1		2	1
Planulina wuellerstorfi	15	9	9	13	2	5	12	7		6		.6	13	8	10	14	12	10	10	3	8	15	14	15	7	13	18	15	7	9	6	13	3	7	6	5	10	4	9	5		5	9	16	5	10	10	12	11	10	6	7	22	9	4	1	5
Plectina apicularis	2																																																				
Epistominella exigua	6	20	9	22	31	18	20	20		28	28	27	2	20	4	9	25	31	14	14	26	18	17	23	6	2	6	18	4	11	15	4	11	13	19	10	20	21	9	7	6	21	16	14	17	6	7	15	37	7	7	13	14	33	38	12	10
E. umbonifera	19	9	6	5	6	11	23	17	14	4	2	3	20	10	16	14	22	3		5	5	6	19	7	22	28	19	30	5	14	11	26	1	8	15	29	4	3	9	5	13	20	6	22	6	28	35	15	5	12	34	47	6	2	29	3	7
Pullenia bulloides	6	9	12	5	8		3	11	8	15	12	3	2	6	4	3	9	7	7	9	6	5	8	9	10	8	13	4	2	9	14	5	4	5	6	5	3	4	4	2	9	6	9	3	4	4	5	5	5	8	9	10	4	1	2	7	6
P. quinqueloba	3				2		2	3	2			1	.8	.8	1	1	7	3																					2										.4	1		3	1	2	1	1	1
P. sp.	2			9		2		4	8	2		3		2	1	2	3			2	2			1	.8	2	1		2	.8		3	1	.7		1			1	1	3		2	2	3	2	3	.4	2	2		4	.4	1	2	
Pyrgo murrhina	2	5			2		2		2		1		.8		3	3	3	5	2		4	3	2	1	3	4	1	2	3	3	3		1			6		.7	2	3	1	1	1	3	.8	1	2	3		4	2	2	1	1	
P. oblonga		7	3			4	1			2	6		.8				1																																						
Quinqueloculina venusta			6						2	3		1		1							3					1	.6				3	1	1										1		2		1			7			3	
Q. cf. weaveri															2									.8	2								.7	1	1				2	.7				1	1								2
Robulus																										.3						.8	1															3				
Sigmoilina tenuis										2		1		2				2										2					.7	1	7	1	3	2												1	2			
Siphotextularia rolshauseni	3	2						5	4		3		.8	1	2	1		2	4	2	5	1	2	1		4	.6	6	9	.8	2		1	1	6	3	2		4	1		3	.6	5	.8	5	2	8	1	3	1	3			1
Spiroloculina sp																																	.7	1																				
Textularia australis																								6	1	1	4	2	2		.8	1	2	.7		1	1	2	4	3	3		4	1	3	5	2	1	3	2		4			1	4
Uvigerina hollicki		5	12	5	4	5	12	7	8	2	5	3	27	7	29	24					6		2	6	4			5	13	18	11	44	25	15		1		45	28	10	28		35	3		1			1		10	12	4	34	29
U. hollicki variant																																					17	28	25															
Valvulineria humilis	3	7		5			1																																														
Virgulina advena					8					5				1				2		1												2							.7		2										2	1		1
V. bradyi																					1				.8													1	3	1	1		3	3	1								
V. complanata																				1																																			

TABLE 30. Occurrences of Foraminifera in selected samples from Core 281 in percent of total population. Planktonic and benthonic populations computed separately.

| CORE 281 | DEPTH-4,281 M. | | |

TABLE 32. Occurrences of Foraminifera in selected samples from Core 288 in percent of total population. Planktonic and benthonic populations computed separately.

| CORE 288 | DEPTH - 2,684 M. | | |

TABLE 33. Occurrences of Foraminifera in selected samples from Core 289 in percent of total population. Planktonic and benthonic populations computed separately.

| CORE 289 | DEPTH - 2640M. | | |

TABLE 34. Occurrences of Foraminifera in selected samples from Core 290 in percent of total population. Planktonic and benthonic populations computed separately.

| CORE 290 | DEPTH-1,995 M. | | |

TABLE 36. Occurrences of Foraminifera in selected samples from Core 293 in percent of total population. Planktonic and benthonic populations computed separately.

| CORE 293 | DEPTH-3,485 M. | | |

TABLE 38. Occurrences of Foraminifera in surface sediment samples in percent of total population. Planktonic and benthonic populations computed separately.

| SAMPLE No. | ALBATROSS | | |

Interpretation of Core Faunas

Recognition of faunal sequences. Interpretations of the vertical sequence of the faunas in the long cores are summarized in Figures 22 to 26. The faunal changes shown by the modern type assemblages are all based upon what is known of the distribution of the modern planktonic species. New information on these distributions is summarized on Figures 3 to 19 and is described in a previous section.

The criteria used in interpreting the vertical sequences depend upon whether a core was collected from mid- or low latitude. The following cores are from mid-latitude locations and are expected to contain the normal mid-latitude faunas for their locations: 215—223, 276—296. The remainder of the cores are relatively low-latitude in position and contain a typical low-latitude fauna.

Faunal variations in the mid-latitude cores are shifts to faunas which appear to be characteristic of somewhat higher latitudes. Recognition of this higher-latitude assemblage is based largely upon the decrease in percentage of *Globorotalia truncatulinoides* and increase in percentage of *Globigerina pachyderma*. Other criteria which seem to be of significance in some samples is the disappearance of the *Globorotalia menardii-tumida* group and *Pulleniatina obliquiloculata*, slight decrease in percentage of *Globigerina inflata* and *Globigerinoides sacculifera*, and increased frequency of *Globigerina bulloides*. These latter criteria do not seem to apply in many cores.

In the low-latitude cores the recognition of a mid-latitude fauna is based largely upon the decrease in frequency of *Globorotalia menardii-tumida* and *Pulleniatina obliquiloculata* and the presence or marked increase of *Globigerina inflata* and/or *Globorotalia truncatulinoides*. *Globigerina bulloides*, *G. pachyderma*, and *Globorotalia scitula* also may be present in the mid-latitude faunas identified from the low-latitude cores.

It does not appear feasible to attempt to establish more definite, numerical criteria for recognizing these mid- and low-latitude faunas in the cores. Our knowledge of the distribution of the modern faunas present in surface sediment samples is very inadequate; also, there is relatively little information on the distribution of living planktonic Foraminifera from plankton hauls. Data from plankton hauls given by Schott (1935) and Phleger (1951) demonstrate that while planktonic species are more abundant in the surface 100 m. of water, they also live in significant abundance at much greater depths. The significance of the distribution at depth in terms of temperature adjustments is uncertain. Moreover, Phleger (1951) reports a few living planktonic forms living on or near the bottom from the northwestern Gulf of Mexico. Recently, numerous living planktonic specimens have been identified from undisturbed bottom samples collected from the northeastern Gulf of Mexico. In addition, real knowledge of the ecologic factors which affect the distribution of planktonic Foraminifera is lacking. Conclusions based upon distribution data are only partially reliable and should be supplemented by physiological experiments if we are to have a real understanding of the significance of core distributions.

Mixed planktonic faunas. A few cores contain assemblages which appear to be mixed planktonic faunas, with relatively high percentages of both low- and mid-latitude species. These mixed faunas are tentatively identified from the following: in Core 233, at 390 cm. and 930 cm.; Core 234, at 130 cm., 190 cm., and 980 cm.; Core 236 contains three layers of apparently mixed faunas below 700 cm.; Core 239 at 4 cm.; in Core 242 all samples containing mid-latitude assemblages appear to be mixed faunas.

The positions of all these cores containing mixed faunas are approximately between 0°—7° N Lat. and 18°—25° W. Long. This is off the coast of Africa, south of Cape Verde.

It is suggested that the modern mixed planktonic assemblage described in a previous section is the result of the convergence of tropical and mid-latitude waters containing different assemblages of planktonic Foraminifera. The present convergence area is located at approximately 20°—25° N Lat., also off the coast of Africa, but north of Cape Verde. These data strongly suggest that at some times during the past the convergence area has shifted southward at least 10° or 15° of Latitude. If this suggested interpretation is correct, then the position of the North Equatorial Current and also the Trade Winds belt may also have shifted southward by this amount at some times during the past.

Displaced faunas. There are several benthonic faunas in the present cores which contain species at present characteristic of shoaler water than the depths at which they were collected in the cores. Some of these assemblages are mixed with the normal deep-water benthonic species and some are relatively pure shallow-water assemblages. The displaced benthonic faunas are found in the following Cores: 215, 217, 221, 228, 248, 252, 257, 258, 262, and 267. These displaced faunas are located in the following areas: the displacement in Core 215 near the Canary Islands; Cores 221 and 228 near the Cape Verde Islands; Cores 248, 252, 257, 258 and 262 in a line parallel to the coast and about 300 to 400 miles off the coast of South America, from 2° N. Lat. to off the Orinoco River; Core 267 near Puerto Rico in the West Indies. The striking fact about the positions of all these cores is that they are relatively near areas of considerable submarine relief. None of the cores collected at great distances from areas of high relief contains the shallow-water, mixed benthonic assemblage.

The layers in the cores containing displaced benthonic faunas vary considerably in thickness. Core 221, from near the Cape Verde Islands, contains a mixed deep and shallow-water benthonic assemblage in most of the samples throughout its 560 cm. of length. Core 228, from near the Cape Verde Islands, also is believed to contain much displaced material throughout its 430 cm. Core 252, from off South America, appears to contain two separate displaced layers each of which is approximately 200 cm. in thickness, separated by a layer showing no evidence of displacement. Core 257, from off the Amazon River, contains a section of displaced material in the bottom of the core greater than 400 cm. in thickness. Core 258, also from off the Amazon River, contains 175 cm. of displaced material at the bottom of the core, and in addition at least two thin layers of displaced material at higher levels. In Core 262 a thin layer containing displaced Foraminifera is present only in the bottom sample at 1279.5—1280 cm. Core 267, from the West Indies region, is composed of *Globigerina* ooze and contains displaced materials throughout its entire 1180 cm.

Most of the core sections containing displaced benthonic species also contain abundant sediment of sand sizes. Core 221 is one of the more striking examples. The top 115 cm. is essentially sand and below that depth there are numerous thin sand layers and lenses. The sand is composed of relatively large quartz grains some of which are rounded and polished. There are abundant mollusc shell fragments in several places, many of which are well-rounded, and rugose ostracods are recorded from some samples. In Core 228 there is abundant fine sand, some in layers, and much mixed with mud. The thick displaced layer in Core 257 contains a series of relatively thin layers of sand and mud. In Core 267 no evidence of sand was seen in 120 thin samples examined; the entire core is a *Globigerina* ooze.

The presence of shallow-water benthonic Foraminifera in sediments collected from deep water seems to be valid proof of displacement

of the specimens and either part or all of the enclosing sediment from shallow water. The presence of normal deep-water benthonic species along with the shallow-water types or enclosing pure layers of them is additional proof. Submarine turbidity currents have been widely discussed in recent years by Kuenen (1951), Menard and Ludwick (1951), Shepard (1951), Ericson *et al* (1952), and others. Phleger (1951 a) has discussed the presence of displaced faunas from various parts of the world, and has suggested slightly different mechanisms for emplacement of different kinds of assemblages.

It is not the purpose of this paper to discuss the possible mechanisms of movement of this sediment which has been displaced downslope. A few generalizations can be made, however, on the data already presented. Presence of displaced layers of thicknesses ranging from only a few millimeters to a few meters, suggests that there may be considerable variation in the amount of displaced material and/or the distance which it was displaced. A series of displaced layers in the same core indicates that displacement may occur at numerous different times at the same place and over a long period of time. The occurrence of thick displaced layers off South America at least 300 miles from the nearest known source indicates that large amounts of material may move for considerable distances. In addition, displaced sand in deep water is only to be expected relatively near areas of considerable submarine relief.

Fossil faunas. Four fossil planktonic species and one fossil benthonic species are recorded from the cores, as follows:

Globigerina altispira
G. venezuelana
Globorotalia sp. 2
Sphaeroidinella rutschi
Cassidulina reflexa

In addition, there are two previously undescribed benthonic species associated with the known fossil forms: *Bolivina* sp. 2 and *Buliminella* sp. These species occur only in Core 233. They are not referred to in the core description. *Globorotalia* sp. 2, although undescribed also, is included since it is found more frequently and shows an interesting distribution. It has been observed in a Bowden Marl sample from Jamaica.

Globorotalia multicamerata has not been included in the above lists but is found associated with or slightly above the other fossil forms in the cores. It has been reported only from the Miocene with the exception of one report from the Recent near Cuba by Cushman and Bermudez (1949, p. 30). It is suggested that this occurrence may be due to reworking or contamination.

The previously reported occurrences of the fossil species in the general West Indian-Caribbean region are given in the species discussions above. The suggested age of the benthonic species is from the upper Middle Miocene since two of the species, *Buliminella* sp. and *Cassidulina reflexa* are found in material from Haiti of this age. This is further corroborated by the evidence of the planktonic species which show an overall range from Middle Oligocene through Middle Miocene although some species extend above or below these limits.

One or more of these fossil species occur in four of the present cores. Core 234 contains the following forms which appear at or somewhat above 1119.5 cm.: *Globigerina altispira*, *G. venezuelana*, *Globorotalia multicamerata*, and *Spaeroidinella rutschi*. *Globorotalia* sp. 2 appears at 1019.5 cm. In Core 238 fossils appear as follows:

Cassidulina reflexa: 1030—1084 cm.
Globigerina altispira: 1090 cm. to bottom
G. venezuelana: 1090 cm. to bottom

There is no faunal evidence for displacement in either Core 234 or 238. The Miocene mate-

rial in Core 234 is more compact, and it appears probable that there is a disconformity between the Miocene and younger sediment. There is no evidence for such a disconformity in Core 238, and it seems possible that it represents more or less continuous deposition. All the modern planktonic species, except *Globorotalia tumida*, occur with the middle Tertiary assemblage and evidently have a range back to the Miocene. There is a possibility that *Globorotalia multicamerata* and *G.* sp. 2 may have a somewhat higher geologic range than the other fossil species, since they usually occur higher in the cores.

In Core 233 the following fossil species occur in three samples below 800 cm.: *Globigerina altispira*, *G. venezuelana*, *Globorotalia multicamerata*, *G.* sp. 2, *Bolivina* sp. 2, *Bulimina* sp. and *Cassidulina reflexa*. This assemblage suggests a Middle Miocene age. There is a possibility that this lower section contains reworked Miocene fossils since they occur only at 801—802 cm. and at 1248—1300 cm., or the entire lower section may be of Miocene age.

The above three cores are found in a northwest-southeast line paralleling the coast of Africa and are placed between 0° and 7° N Lat. They bear no common relationship to underwater topography but do bear roughly the same relationship to the coast of Africa.

Globigerina altispira and *G. venezuelana* occur below 610 cm. in Core 267 and *Globorotalia* sp. 2 occurs in a few samples from 90 cm. to the bottom of the core. This core is shown to contain evidence of displacement for the entire core (see p. 00). The fossil planktonic forms may have been displaced from a shoaler depth or they may have been deposited in place. The sequence of the fossils and displaced species suggests that displacement was taking place during the late Miocene, and possibly Pliocene.

The middle Tertiary sections in these cores reveal some interesting facts not shown in previous stratigraphic studies. These consist of the downward range of several planktonic species not hitherto known below the Pliocene. The deep-ocean nature of these deposits may explain this extension since previous stratigraphic work is based on relatively few deep-sea deposits. The ranges of these species have been obtained from the study of papers by Grimsdale (1952) and others. The species include *Candeina nitida*, *Globigerina eggeri*, *Globorotalia hirsuta*, and *G. punctulata*. The last species has not been reported below the Recent, but may have been listed under other names although not apparently so in the West Indian-Caribbean region. Although *Globigerina eggeri* is not reported in the Miocene it is possible that Miocene reports of *G. dubia* refer to this species. These above occurrences are exclusive of Core 267 which shows displacement. The benthonic species, aside from the known fossil forms, appear to range throughout the cores showing fossil sections and have not been analyzed due to the scarcity of information on the ranges of many of the species.

Correlation of faunas. Correlation of post-Miocene, and particularly post-Pliocene planktonic Foraminifera faunas between deep-sea cores is difficult and may not be possible. The species are modern ones and although minor variations having age significance may be established with further, detailed study, there are no presently recognized extinct species or varieties in this age range. *Globorotalia tumida* (*sensu strictu*) appears to be useful in having a lower limit of range, but this species does not occur in all cores. The only apparent general means of correlation of these microfaunas is by matching supposed similar events based upon faunal interpretations. It can be inferred, for example, that the uppermost »colder-than-modern» fauna in all the cores are correlatives. Likewise, successively lower »warm» and »cold» water

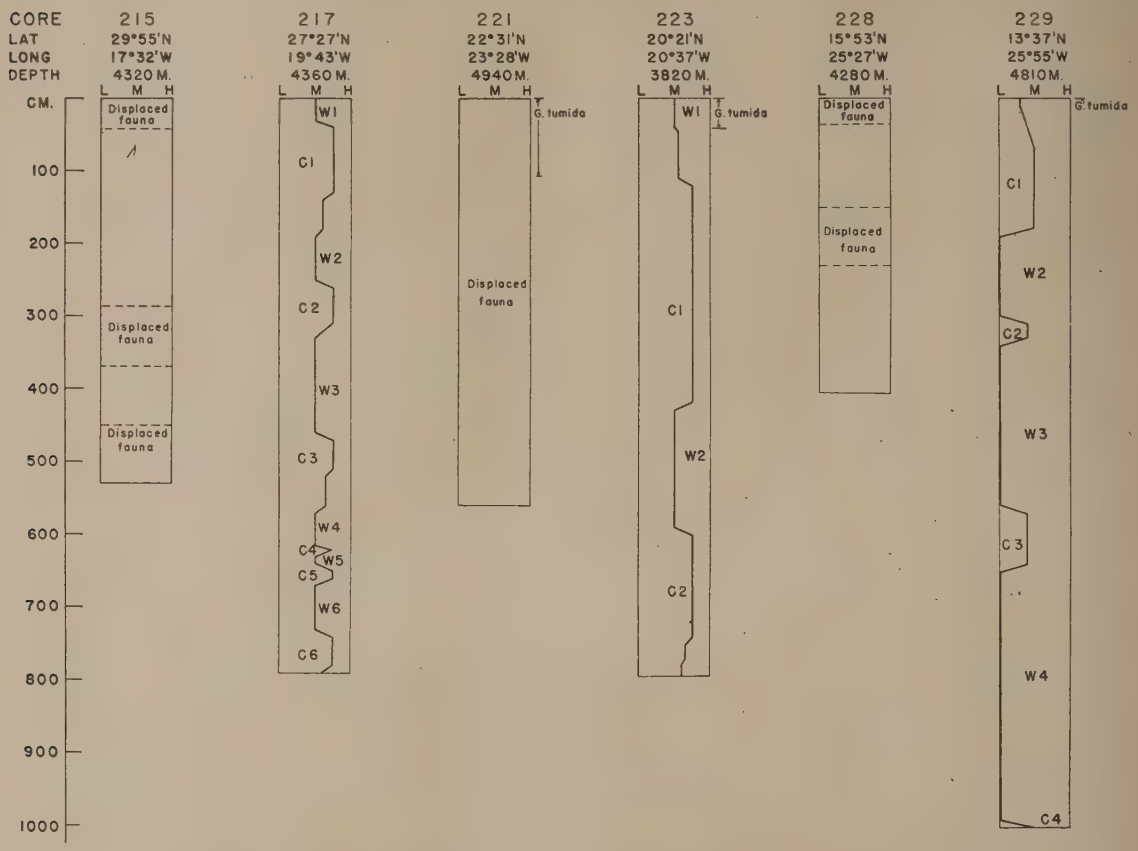

Fig. 22. Interpretations of Foraminifera faunas in Cores 215, 217, 221, 223, 228 and 229. L, low-latitude fauna; M, mid-latitude fauna; H, high-latitude fauna. C, colder-than-present; W, warm-as-present.

faunas in the various cores can be interpreted as having been deposited at the same time. Correlation is based, therefore, on matching a series of events which in turn are based on ecological interpretations of the microfaunas.

Interpretations of the faunas in the cores, shown in Figures 22 to 26, are based entirely on the planktonic assemblages, as discussed above. Where a lower planktonic fauna in any core is different from the modern one in the same core and like the modern fauna in a higher latitude it is interpreted as representing colder oceanic surface waters. Such a fauna is given the designation »C» on the diagrams in Figures 22 to 26, indicating that it is interpreted as a »colder-than-modern» fauna. Faunas more or less like the modern one at the place where a core was collected are indicated by »W» in the core diagrams to signify approximately »warm-as-modern» surface oceanic water at that place. The modern fauna in any core is labelled »W1», the uppermost »colder» fauna is labelled »C1», and successively lower »cold» and »warm» faunas are given successively larger numbers where the sequence appears to be unbroken by displacement of faunas.

The faunal variations in a core may be quite real but their significance can be questioned. The differences between low-, mid-, and high-latitude faunas have been correlated with the distribution of oceanic surface isotherms. This correlation is imperfect and is based upon few and relatively unreliable data. It is assumed that surface-water temperatures are of primary ecologic importance, and this is not necessarily true, as discussed above. It is possible that

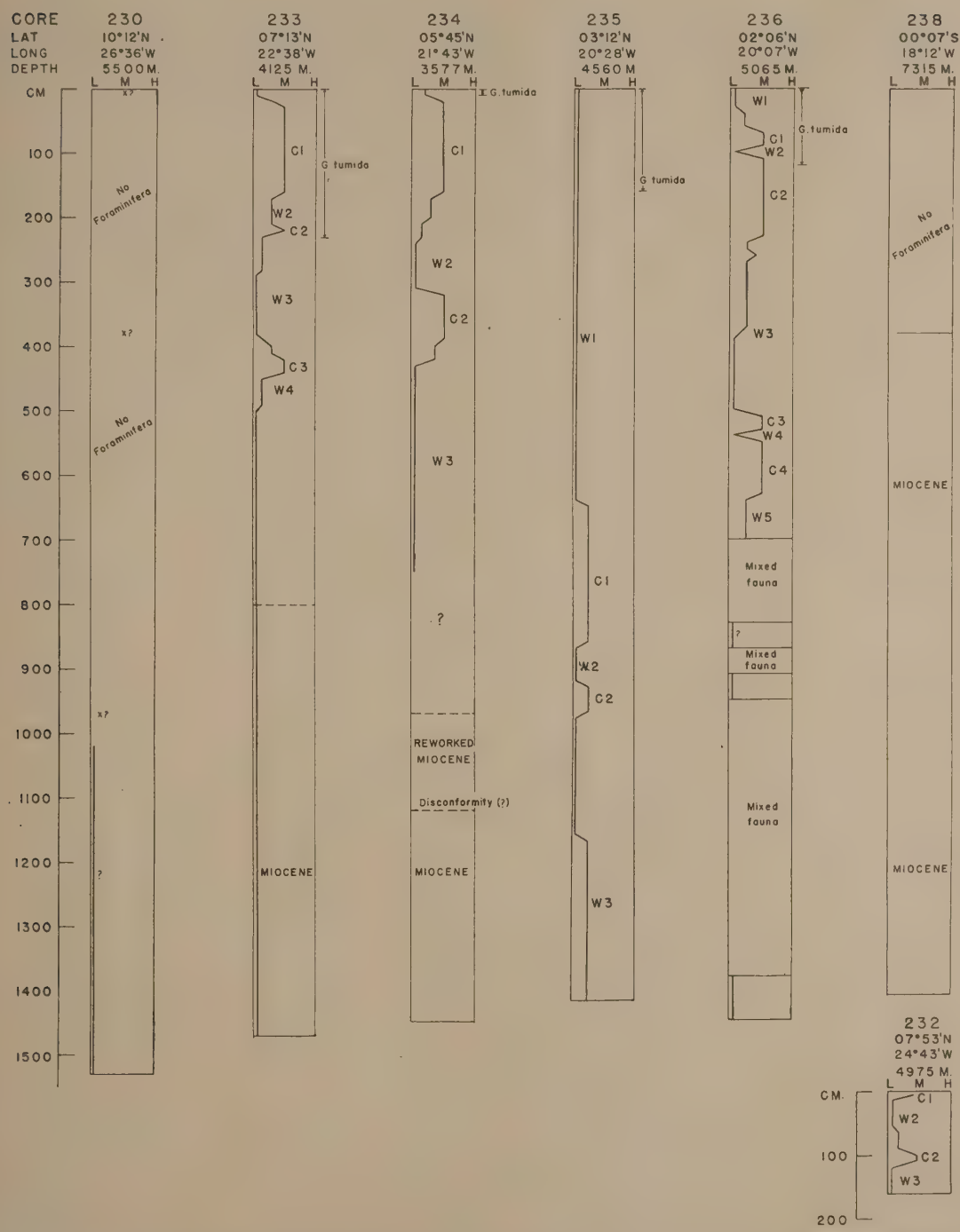

Fig. 23. Interpretations of Foraminifera faunas in Cores 230, 232, 233, 234, 235 and 236. L, low-latitude fauna; M, mid-latitude fauna; H, high-latitude fauna. C, colder-than-present; W, warm-as-present.

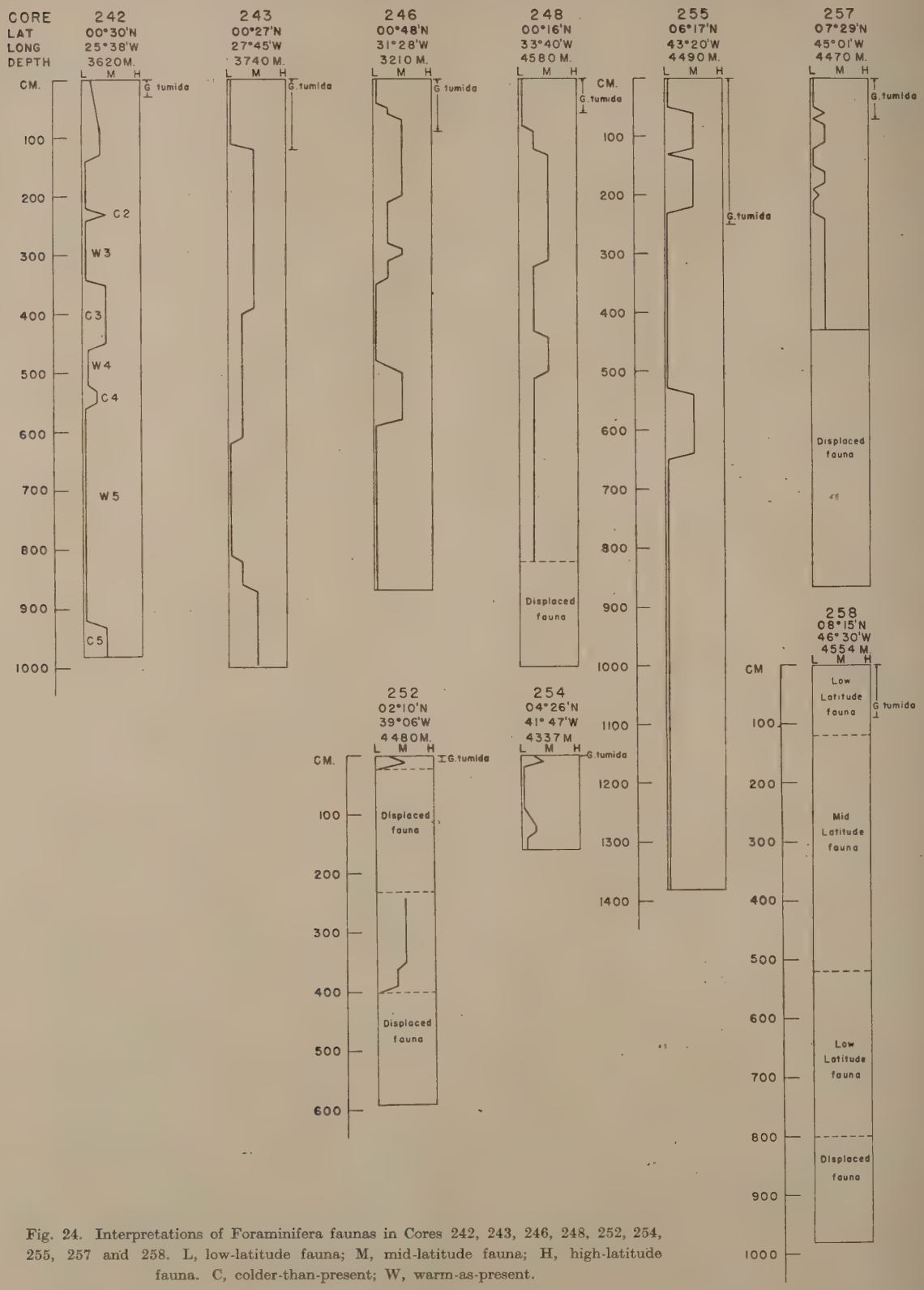

Fig. 24. Interpretations of Foraminifera faunas in Cores 242, 243, 246, 248, 252, 254, 255, 257 and 258. L, low-latitude fauna; M, mid-latitude fauna; H, high-latitude fauna. C, colder-than-present; W, warm-as-present.

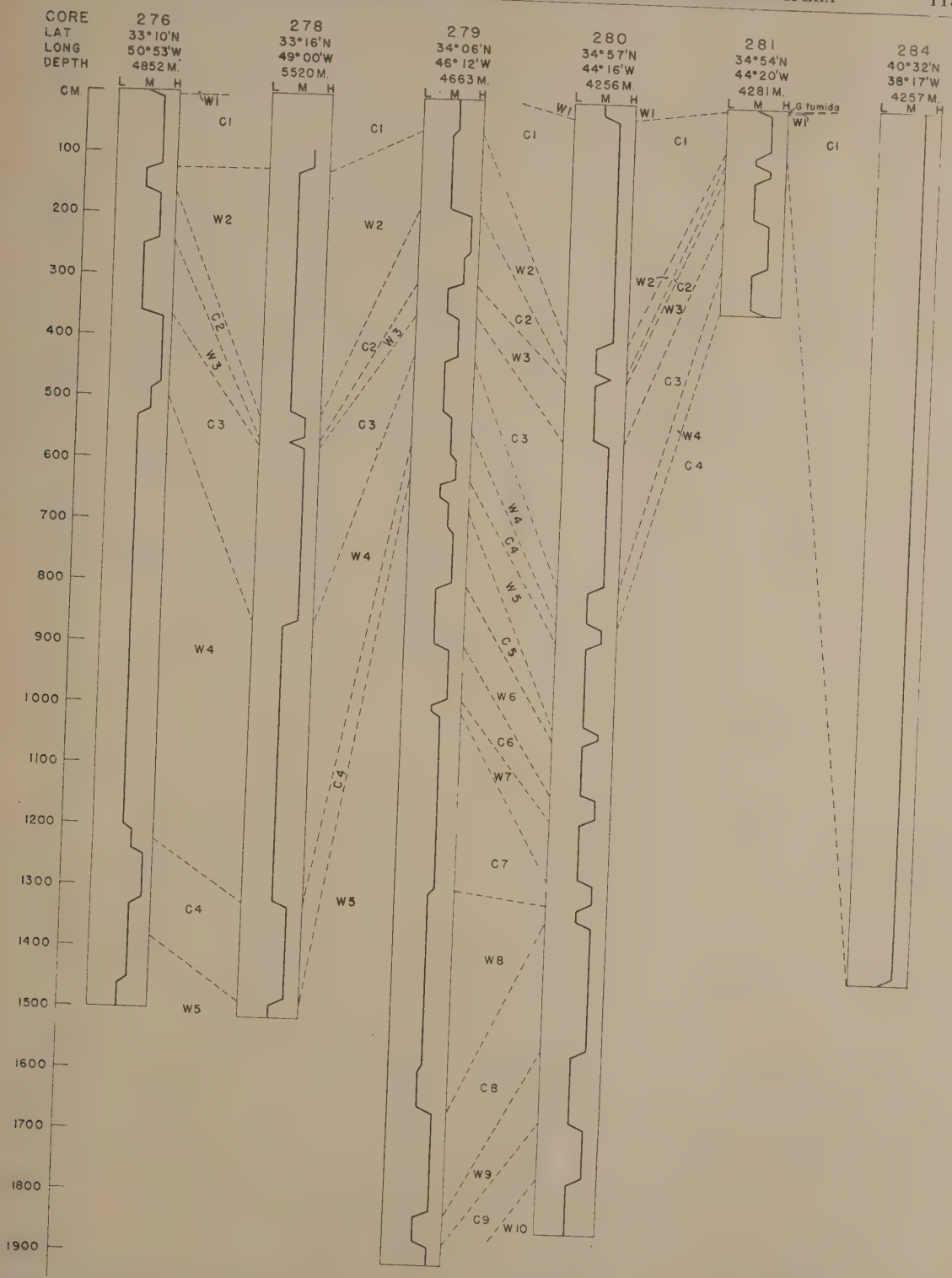

Fig. 25. Interpretations of Foraminifera faunas in Cores 276, 278, 279, 280, 281 and 284. L, low-latitude fauna; M, mid-latitude fauna; H, high-latitude fauna. C, colder-than-present; W, warm-as-present.

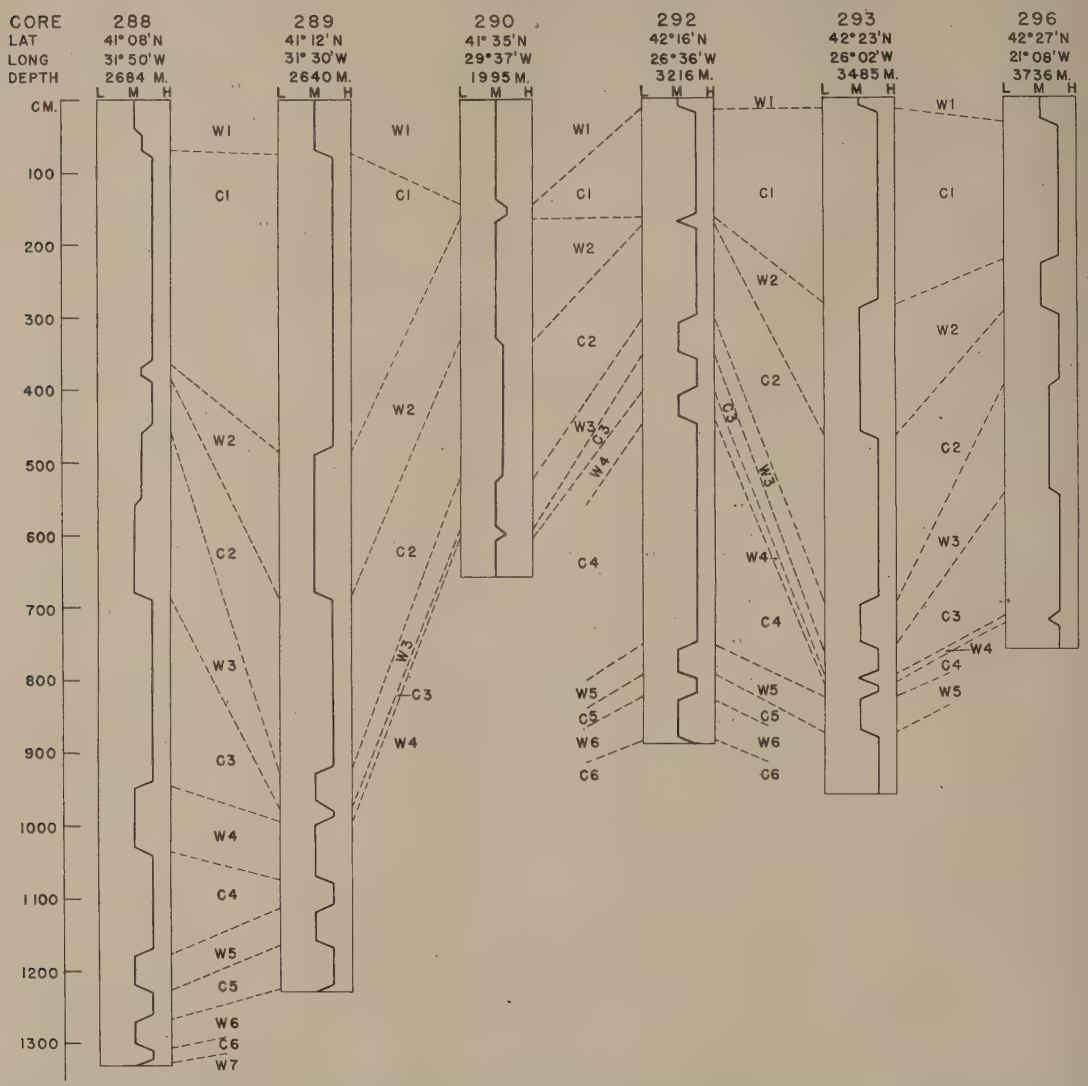

Fig. 26. Interpretations of Foraminifera faunas in Cores 288, 289, 290, 292, 293 and 296. L, low-latitude fauna; M, mid-latitude fauna; H, high-latitude fauna. C, colder-than-present; W, warm-as-present.

some of the faunal variations may be caused by local water mass migrations which are not necessarily of very great over-all significance.

The only series of cores for which we believe there is a good possibility of correlation are those taken in the mid-latitudes in the mid-North Atlantic, between approximately 32° N. Lat. and 42° N. Lat. These cores are the following: 276, 279, 280, 281, 284, 288, 289, 290, 292, 293 and 296. Dashed correlation lines have been drawn between layers where correlation is suggested (Figures 25, 26). It should be emphasized that these correlations are speculative and are to be considered with the qualifications mentioned. It does not seem desirable to attempt to further assign age names to them based upon North American or European Pleistocene chronology.

No attempt is made here to speculate upon the correlation between cores in mid and low latitudes. The »warm» and »cold» faunas are numbered in order, beginning at the top of each

core. It is not intended that these numbers necessarily imply correlation, especially between mid- and low-latitude cores, but it is at least possible that such correlation does exist.

The range of *Globorotalia tumida* (*sensu strictu*) may be of some value in correlation of these cores. This species occurs in the modern fauna and for varying depths below the surface sediment. It appears to extend back only to the last higher latitude fauna (Cl) in all cores where it occurs, with one possible exception. It may be inferred, therefore, that this species is confined to latest glacial and post-glacial times, if we interpret the uppermost higher-latitude fauna as late glacial in age. In general this species is confined to the lower-latitude cores.

Observations on Solution of Calcium Carbonate

Numerous samples from the cores contain a high percentage of broken tests of Foraminifera. Some samples contain essentially no broken tests, others consist only of fragments, and still others contain no evidence of Foraminifera or only a few fragments. Only essentially complete specimens were counted for the faunal list on Tables 2 to 37; the samples having a high population are those with few broken tests and those with low populations generally have a high percentage of broken tests.

Abundant observations of these core faunas seem to indicate that this breakage is fundamentally due to solution of the calcium carbonate causing weakening of the tests and that mechanical causes are secondary. All stages of solution of the calcareous tests have been observed in examination of several hundred thousand specimens in the course of this study. Solution may be well illustrated by the specimens of *Globorotalia menardii-tumida* shown on Plate 12. The figures on this plate show progressive stages of solution observed in different specimens of this species. These specimens are typical of the solution effects observed in *G. menardii-tumida* and are duplicated in several hundred samples, although all solution stages shown are not necessarily seen in every sample where solution has occurred.

Some planktonic Foraminifera species appear to be dissolved more readily than others. Many or most of the *Globigerina* species appear to be attacked before the *Globorotalia* species; *Pulleniatina obliquiloculata* seems to be the last to be destroyed. Many samples contain only pieces of the thick keels of *Globorotalia menardii-tumida* and a few complete specimens of *Pulleniatina obliquiloculata*. It is quite obvious that a fauna containing these two species would have had a large population and consist of several planktonic species. This apparent difference in rate of solution probably is due to the structure of the test wall. The test of most species of *Globigerina* appears to be more porous than that of *Pulleniatina*, for example, and the thickened keel of *Globorotalia menardii-tumida* is the most massive part of this test. Partial solution of *Globigerina* specimens causes them to be more fragile than fresh specimens and thus more easily broken.

The benthonic species observed in the cores were for the most part unbroken and showed no signs of solution. It is possible that their tests are contructed to resist solution in their natural environment — an environment which is alien to the planktonic species.

Observations have been made on solution effects in the surface faunas from the short cores. There is wide variation from no evidence of solution to essentially complete solution of the fauna. In general, the samples from shallower depths show little solution effect and those from depths greater than approximately 5,000 m. show intensive solution, but there are some rather striking exceptions. Samples 242, 243 and 246 from 3,210 to 3,740 m. contain fresh faunas as also do samples 288 from 2,684 m., and 292 from 3,216 m. Samples 224, from 2,810 m. and 225, from 2,973 m., on the

other hand, contain 30—40 % of broken specimens attributed to solution. Samples 247 from 4,285 m. and 257 from 4,470 m. show little solution effect, whereas, in sample 252 from 4,480 m. approximately 90 % of the specimens are broken and there is abundant evidence of solution. Sample 283 from 4,940 m. has only a small amount of solution, but sample 261 from 5,128 m. has approximately 95 % broken material and a very low population of complete specimens. Sample 238 from 7,315 m. contains about ten rather fresh specimens of Foraminifera; this suggests that these specimens may have been deposited just previous to the collection. Sample 240 from 7,500 m. contains at least 50 % broken specimens but there is a relatively large population of whole specimens. Sample 271 from 6,310 m., on the other hand, contains no Foraminifera and it may be assumed that the fauna has been completely destroyed. Observations on these samples are cited as examples only; further data are on file at the Marine Foraminifera Laboratory.

One of the striking features of the cores is the presence of layers showing little evidence of solution and others showing intensive solution in the same core. Observations on the relative amount of breakage, and thus solution of the tests, have not been made on all the cores, but the following examples will illustrate this differential layering. In Core 230, from a depth of 5,500 m., 90 % or more of the Foraminifera are broken, except between approximately 1,450 and 1,500 cm. where the material is relatively fresh with only approximately 10 % broken specimens. Core 233 from 4,125 m., 234 from 3,577 m., 235 from 4,560 m., and Core 236 from 5,065 m. all have layers which appear to have been subjected to intensive solution alternating with relatively fresh layers. In Core 238, from 7,315 m., sample 74 contains only about 10 % of broken specimens of a large fauna although most of the Foraminifera in other samples from this core appear to have been destroyed. Likewise, Core 239 from 7,490 m. contains little evidence of solution in the top sample and abundant evidence in other sections of the core.

These observations of solution effects are not quantitative since there is no method obvious to the writers of estimating the amount of calcium carbonate that has been dissolved from the samples. In addition to solution breaks, pitting, and holes, apparent redeposition of calcium carbonate is observed on numerous specimens and some individual calcite crystals are believed to be of secondary origin. It is difficult to explain the observations of solution of calcareous Foraminifera from the deep Atlantic sediments. Most of the faunas from deeper water show abundant evidence of solution, but some are relatively fresh; conversely, some samples from shoaler stations have marked evidence of solution. The abundance or paucity of solution of calcium carbonate may be in part related to the rate of production of the *Globigerina* fauna and thus the rate of supply of calcareous material to the sediment. Where the rate of supply of calcareous tests to the sediment is high, the bottom water may become saturated with calcium carbonate and lose much of its ability to dissolve additional material. A low rate of supply of calcareous tests to the sediment, on the other hand, may have little effect on the calcium carbonate saturation of the bottom water and the solution effect on the Foraminifera population may be marked.

Areal variations in the amount of solution may be caused by a local lowering of the pH of the bottom water. It is also possible that different water masses have slightly different saturations of calcium carbonate. If these differences exist in the deep bottom water, however slight, the result may be marked geographic variation in calcium carbonate solution. The presence of alternating layers showing evidence of intensive solution and layers of fresh calcareous tests suggests that some may occur after burial of the sediment. If post-depositional solution occurs, it must be

selective because the intensity has been different in different layers. It appears more probable, however, that the different layers essentially record the intensity of solution which occurred at or near the sediment-water interface at some earlier time.

Summary Discussion

All the cores studied contain one or several higher-latitude faunas, separated by faunas normal for the latitude, according to our interpretations. It may be assumed that these higher-latitude faunas were deposited during a time of lower sea surface temperatures than those now existing at the position of any core. The colder faunas from Atlantic cores have been interpreted as approximate correlatives of the Pleistocene glacial stages of Europe and North America by Schott (1935), Bramlette and Bradley (1940), Phleger (1939, 1942, 1951) and Phleger and Hamilton (1946). The areas covered by previous studies include the low-latitude areas between Brazil and Africa, the northwestern Gulf of Mexico, the continental slope of the western North Atlantic, and the position of the cable crossing between Newfoundland and Ireland. This is a widespread distribution in the North Atlantic and covers many of the principal areas, although the density of sampling is low and numerös important areas are not covered. None of the cores reported by previous authors exceeds about three meters in length and most are considerably shorter.

It appears quite possible that the uppermost higher-latitude faunas in the Swedish Deep Sea Expedition cores represent times of cooler surface water during a Pleistocene glacial stage. It is possible that some of the lower »cold» and »warm» faunas extend into the Pliocene. The composition of the Miocene faunas is generally a modern low-latitude type; the cores containing this fauna are in low latitudes and it can be assumed that late Miocene conditions were essentially similar to those at present existing.

The »colder» faunas in the low-latitude cores are like our modern mid-latitude faunas, and this suggests that surface temperature conditions were like those now obtaining in mid-latitudes. The mid-latitude »colder» faunas are like those in higher latitudes, suggesting that surface temperature conditions were like those now prevailing north of 43° N Lat. and probably north of about 50° N Lat. This suggests that during the stages cooler than present there was a southward shift of the isotherms. If we assume that the higher-latitude faunas are to be correlated between mid and low latitudes, a general southward shift of the isotherms for the entire North Atlantic is indicated. Since the higher-latitude faunas in the low latitude cores suggest cooler surface temperatures than present ones on those latitudes, it may be concluded that modern tropical sea surface temperatures did not exist in the North Atlantic at times when these faunas were deposited. These data indicate, therefore, a general southward migration of sea surface isotherms during the »cooler» stages and a general lowering of surface temperature in the North Atlantic even in tropical areas. It should be emphasized that these conclusions are speculative and are based on the premises: 1) that the higher-latitude faunas were deposited during times of lower sea surface temperatures, and 2) that the higher-latitude faunas are to be correlated between cores.

The recognition of pre-modern, apparently mixed mid- and low-latitude planktonic faunas from some cores is interesting in this connection. The modern mixed assemblage occurs at the approximate position of the convergence of the Equatorial Counter Current and the Canaries Current water to form the North Equatorial Current, at 15° to 20° N. Lat. off the coast of Africa. The lower mixed corefaunas occur in cores which were collected between

approximately 0° and 7° N. Lat., also off the coast of Africa. These faunas suggest that at the time they were deposited the convergence had moved southward through at least 10° of latitude. It can be assumed that the Trade Winds, or their equivalent, also had shifted southward to an approximately equatorial position. The implications of this are uncertain. It may suggest that the northern hemisphere mid and low-latitude wind belts were displaced toward the southern hemisphere, or it may indicate a telescoping of the wind circulation in equatorial regions. The effect of such a modification of the wind system would be expected to have far-reaching effects on the Atlantic water circulation and therefore far-reaching effects on continental climates.

The widespread occurrence of displaced faunas may be of considerable importance to the deposition of sediment in the North Atlantic. As indicated above, the displaced faunas appear to be located near areas of considerable relief. Data from these cores and from elsewhere (Phleger, 1951) suggest that displaced faunas cover only a small percentage of an ocean basin, even though they may have considerable areal extent. It appears reasonable to assume that sediment being displaced to the deep ocean will carry an assortment of sediment from clay through sand sizes. It is expected that there will be differential sorting of these sizes as the sediment is moved downslope and gradually loses velocity with the sand sizes deposited first, nearest the source. Tests of Foraminifera may be considered as sand particles in their reaction to processes of sediment transportation and deposition so that any Foraminifera which are contained in the sediment will be deposited along with the sand-size material. It is expected that they will be deposited along with grains of sand smaller than the tests themselves since they have a relatively low density per unit volume. The fine silt and clay sizes of the material being displaced will be carried beyond the coarser material and deposited. This fine-grained sediment is expected to carry no tests of Foraminifera since they have been deposited with the sand.

It appears probable that some of the fine-grained sediment in the deep North Atlantic, far from sources of supply, is the fine fraction of displaced sediment. A considerable percentage of sediment in these deep basins thus may be of terrigenous origin. Deposition of the fine sediment by this mechanism should have no effect on the stratigraphic sequence of the planktonic Foraminifera in these sediments. Interpretations of chronology based upon planktonic populations in cores collected from such areas are expected to be as valid as those from any area of the ocean.

Observations on solution of the calcareous core faunas are of possible importance in studying relative rates of organic production, of deposition of sediment, and chronology. Solution observations made on the present cores are not sufficiently specific to warrant definitive applications. If most or all of the solution of calcium carbonate occurs at or near the sediment-water interface, then evidence at lower levels in a core should provide a clue to conditions at the time when any fauna was deposited. Conditions causing intensive solution may have been a relatively low rate of Foraminifera production, and perhaps other factors. It is possible that layers in the sediment containing intensive solution effects and also those containing fresh specimens are either to be correlated from area to area or have related causes. Such interpretations may be of considerable value as a check on rates of deposition estimated from other sources. They may also be of aid in certain interpretations of past environments.

Rate of deposition of deep-sea sediment is a subject on which much has been written and essentially no generalizations can be made. The writers do not intend to review the

voluminous literature containing speculations on this subject. It seems appropriate, however, to summarize our data and the interpretations which appear to apply to this problem.

Examination of the suggested correlations between Cores 276 to 296 on Figures 25 and 26 suggests rather marked differences in relative deposition rates. The greatest contrast is between the thickness of the uppermost higher-latitude faunas (C1) in Cores 281 and 284. In Core 281 this fauna (C1) is approximately 60 cm. thick, whereas in Core 284 presumably the same fauna occurs throughout at least 1,400 cm. of the core, a ratio of more than 20: 1. Core 279 contains four higher-latitude faunas and five normal-latitude in less than 700 cm., while presumably the same sequence occurs in more than 1,500 cm. of Core 278. An examination of Figures 22 to 24 shows that there are significant variations from one core to another. It is probable that relative rates of deposition vary with time at the same location.

Some of this apparent variation in sedimentation rate may, perhaps, be related to supply of fine-grained material from displaced sediments, as discussed above. Some of the relatively fast deposition undoubtedly is related to the deposition of volcanic ash. Abundant pyroclastic material was identified in some of these cores, but no systematic survey was made either of its abundance or distribution. Variations in the rate of production of the planktonic Foraminifera undoubtedly have an important effect on rate of accumulation of mineral detritus in the deep sea. Layers containing large populations of the *Globigerina* ooze assemblage which show little solution effect may indicate high production and rapid deposition.

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Contribution No. 14. Marine Foraminifera Laboratory.

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PLATES

PLATE 1

Figure

1, 2, 6. *Globigerina altispira* Cushman and Jarvis. X 42. Core 234, sample 113.
3, 4, 7, 8. *Globigerina bulloides* d'Orbigny. X 42. ATLANTIS Sta. 4739.
5. *Sphaeroidina bulloides* d'Orbigny. X 70. ATLANTIS Sta. 4637.
9, 10. *Globigerina digitata* H. B. Brady. X 42. (9) Core 267, sample 88; (10) Core 252, sample 70.
11, 12. *Globigerina eggeri* Rhumbler. X 42. Short Core 226 A, sample 1.
13, 14. *Globigerina hexagona* Natland. X 51. Core 243, sample 83.
15, 16. *Globigerina inflata* d'Orbigny. X 42. Core 290, sample 3.
17, 18, 19. *Globigerina pachyderma* (Ehrenberg). X 51. Core 284, sample 1.
20, 21. *Globigerina quinqueloba* Natland. X 70. Core 284, sample 14.
22, 23. *Globigerina* sp. 1. X 70. Core 248, sample 89.
24, 25. *Globigerina venezuelana* Hedberg. X 42. Core 234, sample 113.
26, 27. *Globigerina* sp. 2. X 70. Core 235, sample 129.

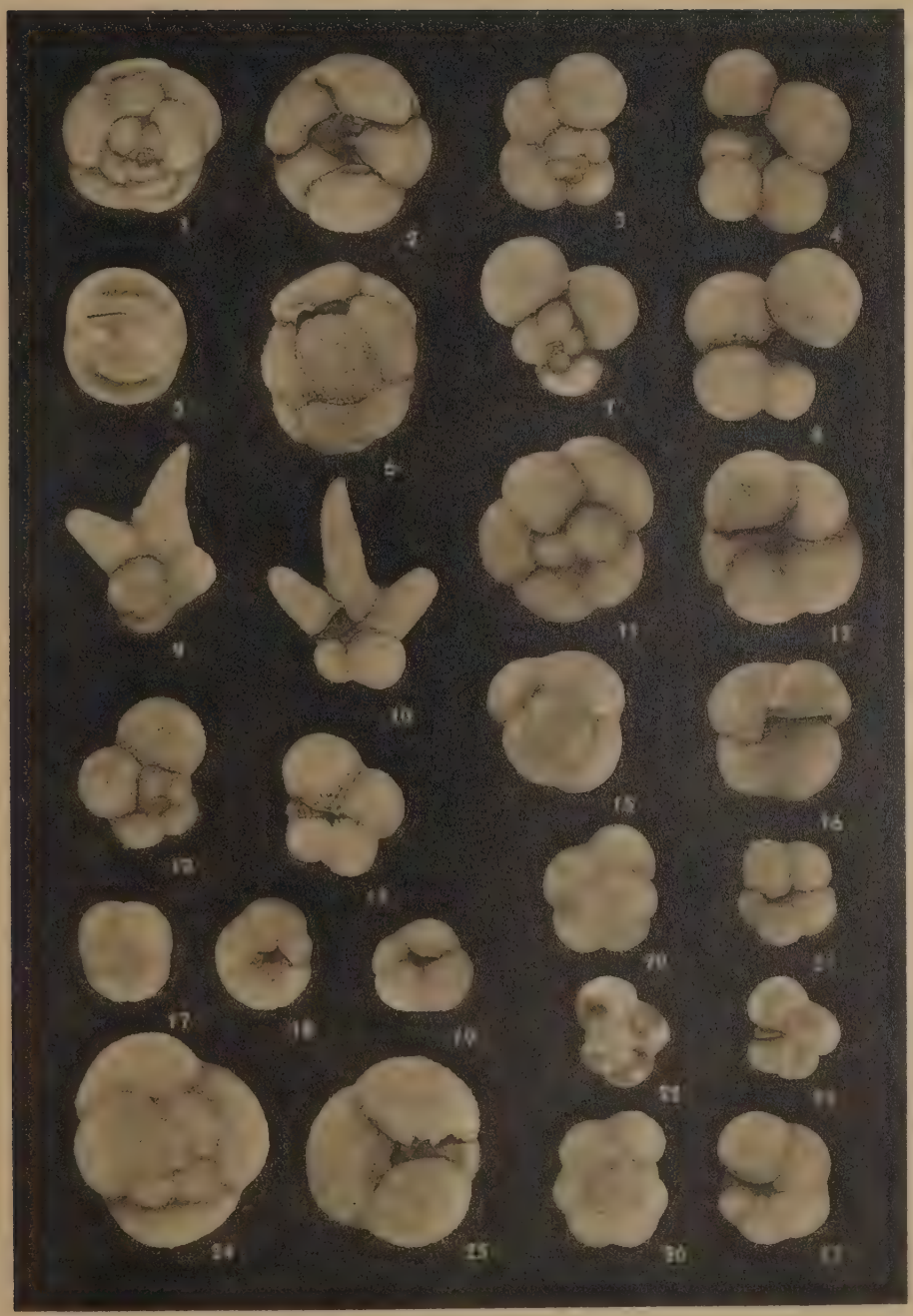

PLATE 2

Figure

1, 2, 3. *Globigerinoides conglobata* (H. B. Brady). X 42. (1, 2) ATLANTIS Sta. 4637; (3) Core 267, Sample 42.

4, 7. *Globigerinoides rubra* (d'Orbigny). X 42. Short Core 226 A, sample 1.

5, 6. *Globigerinoides sacculifera* (H. B. Brady). X 42. Short Core 226 A, sample 1.

8. *Orbulina universa* d'Orbigny. X 42. Short Core 267 A, sample 1.

9, 10, 11. *Globigerinella aequilateralis* (H. B. Brady). X 42. Core 242, sample 58.

12, 13, 14, 15. *Globigerinita glutinata* (Egger). X 51. Core 228, sample 1.

16, 17, 18. *Pulleniatina obliquiloculata* (Parker and Jones). X 42. ATLANTIS Sta. 4637.

19. *Sphaeroidinella dehiscens* (Parker and Jones). X 42. Core 246, sample 48.

20, 21. *Sphaeroidinella rutschi* Cushman and Renz. X 42. Core 234, sample 128.

22, 23. *Candeina nitida* d'Orbigny. X 42. Core 267, sample 1.

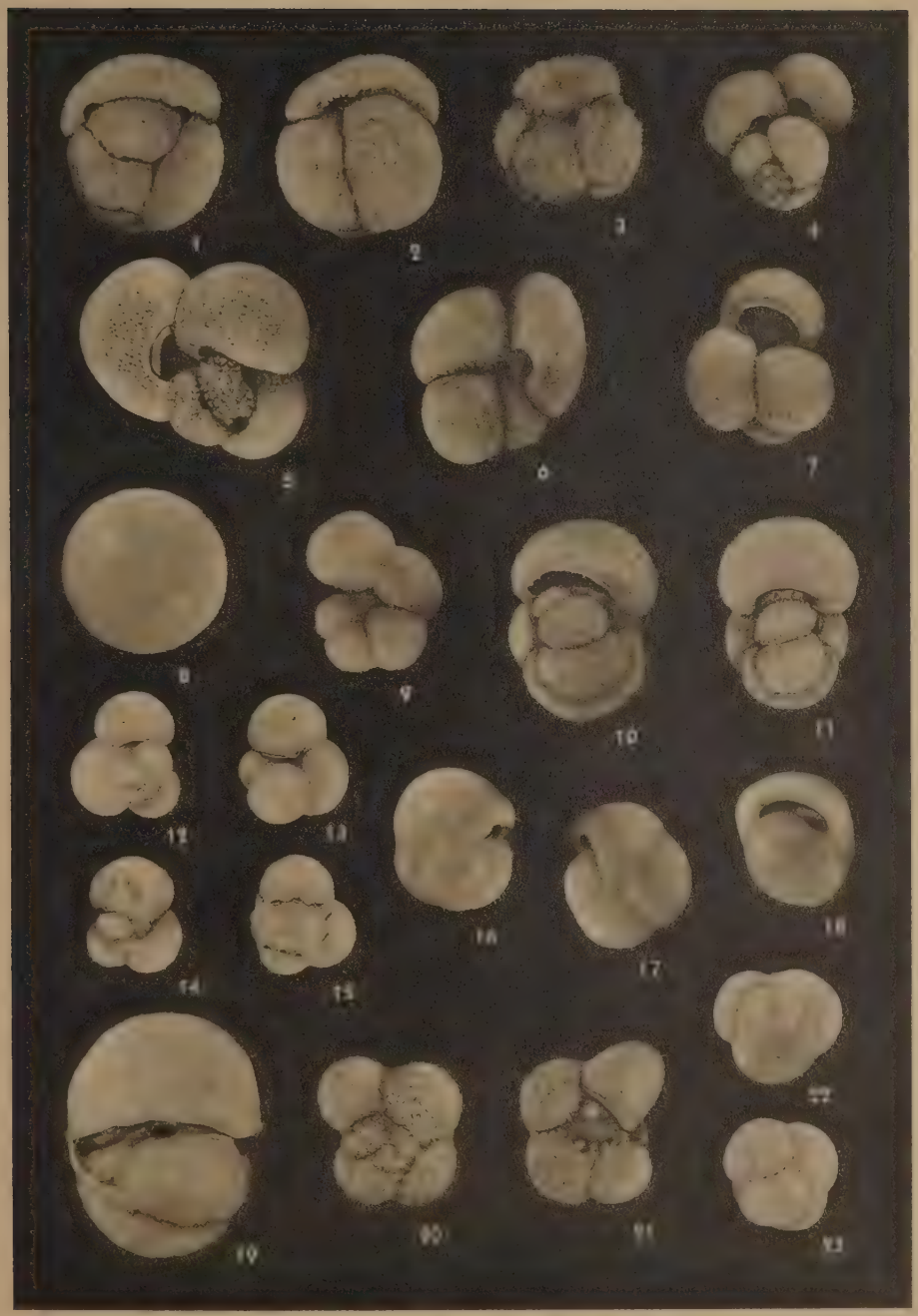

PLATE 3

Figure

1, 2. *Globorotalia menardii* (d'Orbigny). (1) X 31; (2) X 34. Short Core 226 A, sample 1.

3, 6. *Globorotalia tumida* (H. B. Brady). (3) X 34; (6) X 42. Short Core 226 A, sample 1.

4, 5. *Globorotalia menardii* var. (d'Orbigny). X 34. Core 267, sample 20.

7, 8. *Globorotalia tumida* var. (H. B. Brady). X 34. Core 279, sample 143.

10, 11. *Globorotalia tumida* var. (H. B. Brady). X 34. Core 252, sample 68.

9, 12. *Globorotalia multicamerata* Cushman and Jarvis. X 42. Core 234, sample 113.

PLATE 4

Figure

1, 2, 3, 4. *Globorotalia hirsuta* (d'Orbigny). X 42. ATLANTIS Sta. 4637.

5, 6, 7. *Globorotalia hirsuta* var. (d'Orbigny). X 42. Core 289, sample 79.

8, 9, 10, 11, 12. *Globorotalia punctulata* (d'Orbigny). (8, 12) X 34; (9, 10) X 42; (11) X 31. Core 279, sample 152.

13, 14. *Globorotalia scitula* (H. B. Brady). X 42. Core 246, sample 48.

15, 16. *Globorotalia* sp. 2. X 42. Core 252, sample 24.

17, 18. *Globorotalia truncatulinoides* (d'Orbigny). X 42. ATLANTIS Sta. 4637.

19, 20, 21. *Globorotalia* sp. 1. X 42. Core 235, sample 129.

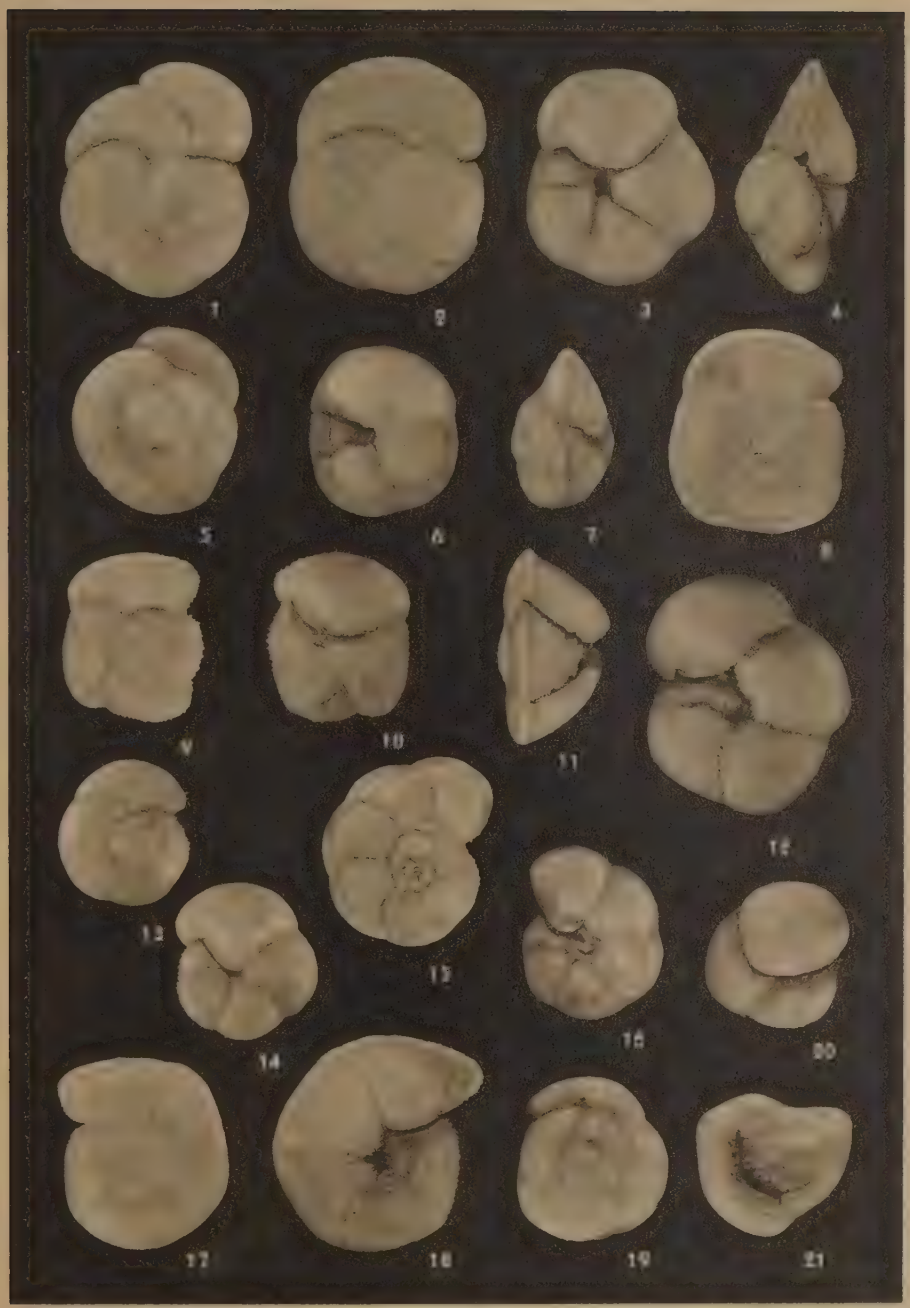
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PLATE 5

Figure

1. *Glomospira charoides* (Jones and Parker). X 70. ATLANTIS Sta. 4735.
2. *Glomospira* cf. *gordialis* (Jones and Parker). X 51. Core 267, sample 1.
3, 4. *Textularia australis* Parr. X 51. (3) Core 279, sample 60; (4) Core 279, sample 53.
5, 6. *Siphotextularia curta* (Cushman). (5) X 42, Core 290, sample 4; (6) X 51, Core 290, sample 5.
7. *Siphotextularia rolshauseni* Phleger and Parker. X 51, Core 280, sample 99.
8, 9. *Eggerella bradyi* (Cushman). (8) X 42; (9) X 51. Core 279, sample 46.
10. *Plectina apicularis* (Cushman). X 51. ATLANTIS Sta. 4637.
11, 12. *Quinqueloculina venusta* Karrer. X 42. Core 288, sample 1.
13, 14. *Quinqueloculina* cf. *weaveri* Rau. X 42. (13) Core 246, sample 4; (14) Core 246, sample 1.
15, 16. *Spiroloculina* sp. X 51. (15) Core 280, sample 109; (16) Core 280, sample 115.
17. *Sigmoilina schlumbergeri* A. Silvestri. X 42. Core 292, sample 37.
18. *Sigmoilina tenuis* (Czjzek). X 51. Core 280, sample 117.
19, 20. *Nummoloculina irregularis* (d'Orbigny). X 51. Core 267, sample 10.
21. *Triloculina tricarinata* d'Orbigny. X 51. Core 289, sample 41.
22, 23, 24. *Pyrgo murrhina* (Schwager). (22, 23) X 34. (24) X 30. (22) Core 284, sample 94; (23) Core 284, sample 56; (24) Core 279, sample 7.
25, 26. *Pyrgo oblonga* (d'Orbigny). X 42. Core 292, sample 73.
27. *Ophthalmidium inconstans* (H. B. Brady). X 51. Core 267, sample 10.
28, 29. *Spirophthalmidium acutimargo* (H. B. Brady). X 51. (28) Core 267, sample 15; (29) Core 288, sample 38.
30. *Cornuspira planorbis* Schultze. X 70. Core 248, sample 89.

PLATE 6

Figure

1, 2. *Trochamnina* cf. *advena* Cushman. X 51. Core 267, sample 1.
3. *Nonion asterizans* (Fichtel and Moll). X 42. Core 221, sample 1.
4. *Nonion barleeanum* (Williamson). X 51. Core 246, sample 82.
5. *Nonion formosum* (Seguenza). X 51. Core 252, sample 24.
6. *Nonion germanicum* (Ehrenberg). X 51. Core 288, sample 9.
7, 8. *Nonion pompilioides* (Fichtel and Moll). X 51. (7) Core 290, sample 59; (8) Core 284, sample 86.
9, 10. *Nonionella atlantica* Cushman. X 51. Core 246, sample 24.
11, 12. *Nonionella sloanii* (d'Orbigny). X 51. Core 252, sample 70.
13, 14. *Nonionella* sp. X 70. Core 252, sample 70.
15. *Elphidium advenum* (Cushman). X 51. Core 221, sample 1.
16. *Elphidium complanatum* (d'Orbigny). X 42. Core 221, sample 1.
17. *Elphidium crispum* (Linné). X 42. Core 221, sample 1.
18. *Buliminella* sp. X 51. Core 233, sample 82.
19, 20. *Robertina bradyi* Cushman and Parker. X 51. (19) Core 288, sample 39; (20) Core 267, sample 27.
21, 22. *Bulimina aculeata* d'Orbigny. X 51. Core 290, sample 31.
23. *Bulimina alazanensis* Cushman. X 51. Core 252, sample 109.
24. *Bulimina exilis* H. B. Brady. X 51. Core 221, sample 56.
25, 26. *Bulimina marginata* d'Orbigny variant. (25) X 70. (26) X 51. Core 257, sample 86.
27. *Bulimina mexicana* Cushman. X 51. ATLANTIS Sta. 4735.
28, 29. *Bulimina* aff. *subacuminata* Cushman and R. E. Stewart. X 51. Core 221, sample 56.
30, 31. *Bulimina translucens* Parker, n.sp. X 70. (30) Holotype; (31) Paratype. ATLANTIS Sta. 4637.
32. *Globobulimina affinis* (d'Orbigny). X 51. Core 288, sample 14.
33, 34. *Globobulimina* (*Desinobulimina*) cf. *turgida* (Bailey). X 42. Core 221, sample 56.

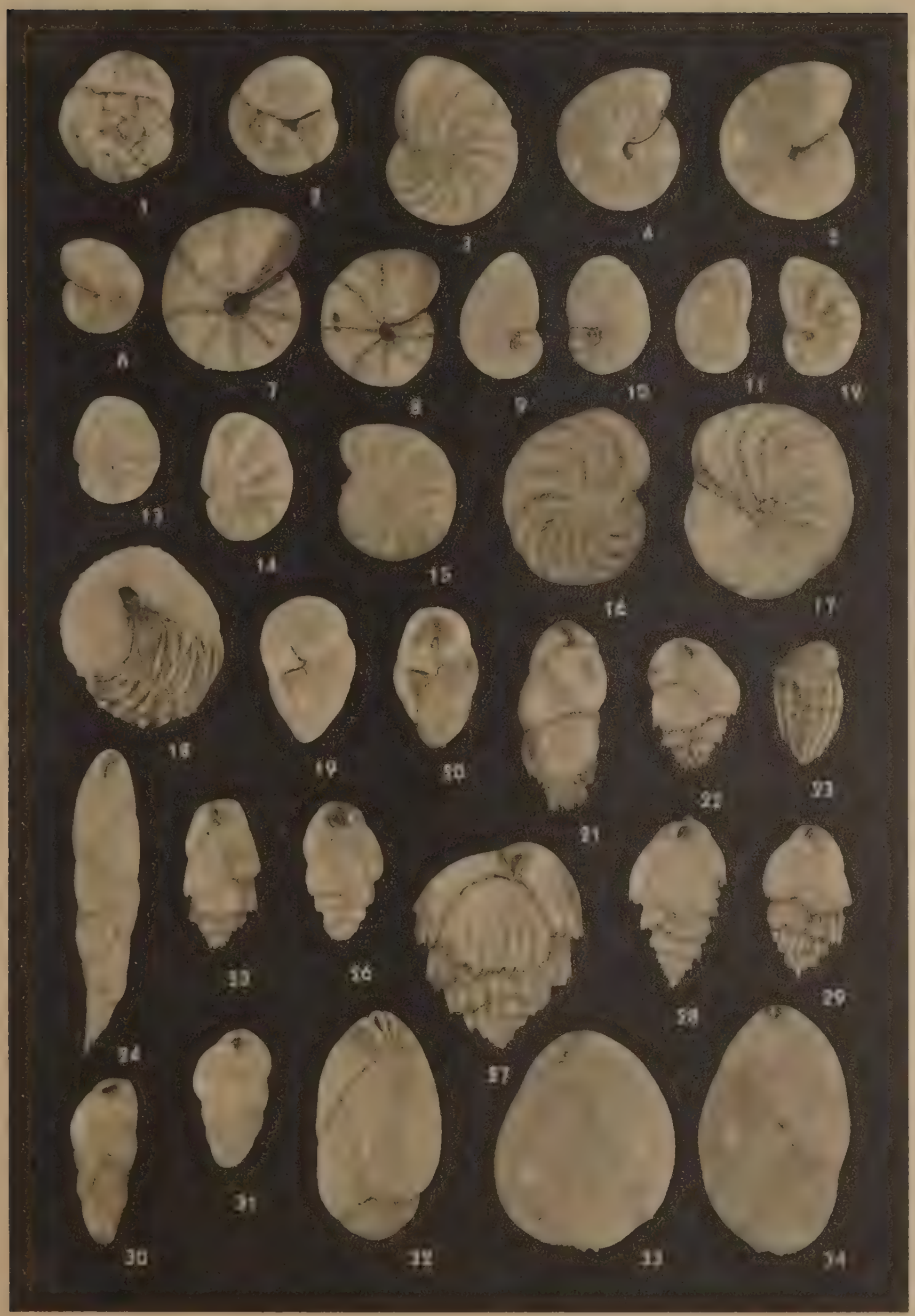

PLATE 7

Figure

1, 2. *Virgulina advena* Cushman. X 51. (1) Megalospheric form, Core 246, sample 69; (2) Microspheric form showing internal structure of aperture, Core 246, sample 56.

3. *Virgulina complanata* Egger. X 51. Core 284, sample 11.

4, 5. *Virgulina bradyi* Cushman. X 42. Core 284, sample 92.

6, 7. *Virgulina mexicana* Cushman. X 51. Core 221, sample 56.

8. *Virgulina tessellata* Phleger and Parker. X 70, Core 252, sample 9.

9, 10. *Virgulina* sp. X 70. Core 284, sample 11.

11. *Bolivina globulosa* Cushman. X 70. Core 267, sample 80.

12. *Bolivina* cf. *minuta* Natland. X 70. Core 290, sample 1.

13, 14. *Bolivina paula* Cushman and Cahill. X 70. (13) Core 267, sample 37; (14) Core 252, sample 19.

15, 16, 17. *Bolivina petterssoni* Parker, n. sp. (15) X 50, Holtype; (16, 17) X 51, Paratypes. Core 221, sample 56.

18, 19. *Bolivina pseudoplicata* Heron-Allen and Earland. (18) X 70. Core 267, sample 1; (19) X 51. Core 228, sample 4.

20, 21. *Bolivina pseudopunctata* Höglund. X 51. Core 284, sample 11.

22. *Bolivina pulchella* (d'Orbigny). X 70. Core 248, sample 92.

23. *Bolivina pusilla* Schwager. X 51. Core 290, sample 64.

24, 25. *Bolivina subaenariensis* Cushman. (24) X 42. (25) X 51. Core 257, sample 86.

26. *Bolivina tortuosa* H. B. Brady. X 51. Core 252, sample 24.

27, 28. *Bolivina* sp. 1. X 51. Core 221, sample 10.

29. *Bolivina* sp. 2. X 51. Core 233, sample 132.

30, 31, 32. *Uvigerina auberiana* d'Orbigny. X 51. (30) Core 290, sample 64; (31) Core 290, sample 9; (32) Core 290, sample 31.

33, 34, 35. *Uvigerina auberiana* d'Orbigny variants. (33) X 51. Core 290, sample 54; (34) X 42. (35) X 30. Core 267, sample 15.

PLATE 8

Figure

1. *Uvigerina hollicki* Thalmann. X 42. Core 284, sample 11.
2, 3. *Uvigerina hollicki* Thalmann variants. X 42. (2) Core 290, sample 64; (3) Core 284, sample 109.
4, 5. *Uvigerina senticosa* Cushman. X 51. Core 221, sample 56.
6. *Uvigerina* sp. 1. X 70. Core 257, sample 86.
7. *Uvigerina* sp. 2. X 70. Core 257, sample 87.
8. *Rectuvigerina* sp. X 51. Core 228, sample 16.
9. *Angulogerina selseyensis* (Heron-Allen and Earland). X 70. Core 267, sample 48.
10, 11, 12, 13. *Pleurostomella acuminata* Cushman. X 51. (10) Core 234, sample 138; (11) Core 234, sample 130; (12, 13) Core 242, sample 90.
14. *Patellina corrugata* Williamson. X 70. Core 248, sample 89.
15 a, b. *Discorbis bertheloti* (d'Orbigny). X 42. Core 257, sample 88.
16, 17. *Discorbis* cf. *columbiensis* Cushman. X 70. Core 267, sample 37.
18, 23, 24. *Discorbis mamilla* (Williamson). (18, 24) X 70. Core 228, sample 4; (23) X 51. Core 215, sample 48.
19, 20, 21, 22. *Discorbis williamsoni* Parr. X 51. (19) Core 290, sample 60; (20) Core 290, sample 64; (21, 22) Core 228, sample 1.
25, 26, 27, 28. *Discorbis obtusa* (d'Orbigny). (25, 26) X 42. Core 215, sample 48; (27) X 51. (28) X 70. Core 246, sample 24.
29, 30. *Valvulineria araucana* (d'Orbigny). X 51. Core 267, sample 1.
31, 32. *Valvulineria humilis* (H. B. Brady). X 70. ATLANTIS Sta. 4637.
33, 34. *Gyroidina lamarckiana* (d'Orbigny). X 51. Core 217, sample 19.
35, 36. *Gyroidina orbicularis* (d'Orbigny). X 51. Core 290, sample 4.

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PLATE 9

Figure

1, 2. *Gyroidina soldanii* d'Orbigny variants. X 51. Core 217, sample 19.

3, 4. *Eponides polius* Phleger and Parker. X 70. Core 246, sample 1.

5, 6. *Eponides pusillus* Parr. X 70. Core 284, sample 25.

7, 8. *Eponides tumidulus* (H. B. Brady). X 70. Core 246, sample 1.

9, 10. *Eponides umbonatus* (Reuss). X 51. Core 279, sample 23.

11, 16. *Osangularia cultur* (Parker and Jones). X 42. Core 246, sample 48.

12, 13, 14, 15, 17, 18. »*Rotalia*» beccarii (Linné) variants. X 51. (12, 13, 14, 15) Core 221, sample 1; (17, 18) Core 257, sample 86.

19, 20, 21. »*Rotalia*» *praegeri* (Heron-Allen and Earland). X 51. (19) Core 290, sample 21; (20) Core 290, sample 26; (21) Core 290, sample 16.

22, 23. »*Rotalia*» *translucens* Phleger and Parker. X 70. Core 228, sample 4.

24, 25. *Höglundina elegans* (d'Orbigny). (24) X 34. (25) X 42. Core 267, sample 10.

26, 27. *Cancris* cf. *oblonga* (Williamson). X 51. Core 221, sample 56.

28, 29. *Amphistegina lessonii* d'Orbigny. X 70. Core 267, sample 10.

30, 31. *Tretomphalus atlanticus* Cushman. X 51. Core 228, sample 1.

32, 37. *Cassidulina carinata* A. Silvestri. X 51. Core 290, sample 60.

33, 34. *Epistominella* (?) *umbonifera* (Cushman). X 51. Core 284, sample 105.

35, 36. *Epistominella exigua* (H. B. Brady). X 51. Core 292, sample 19.

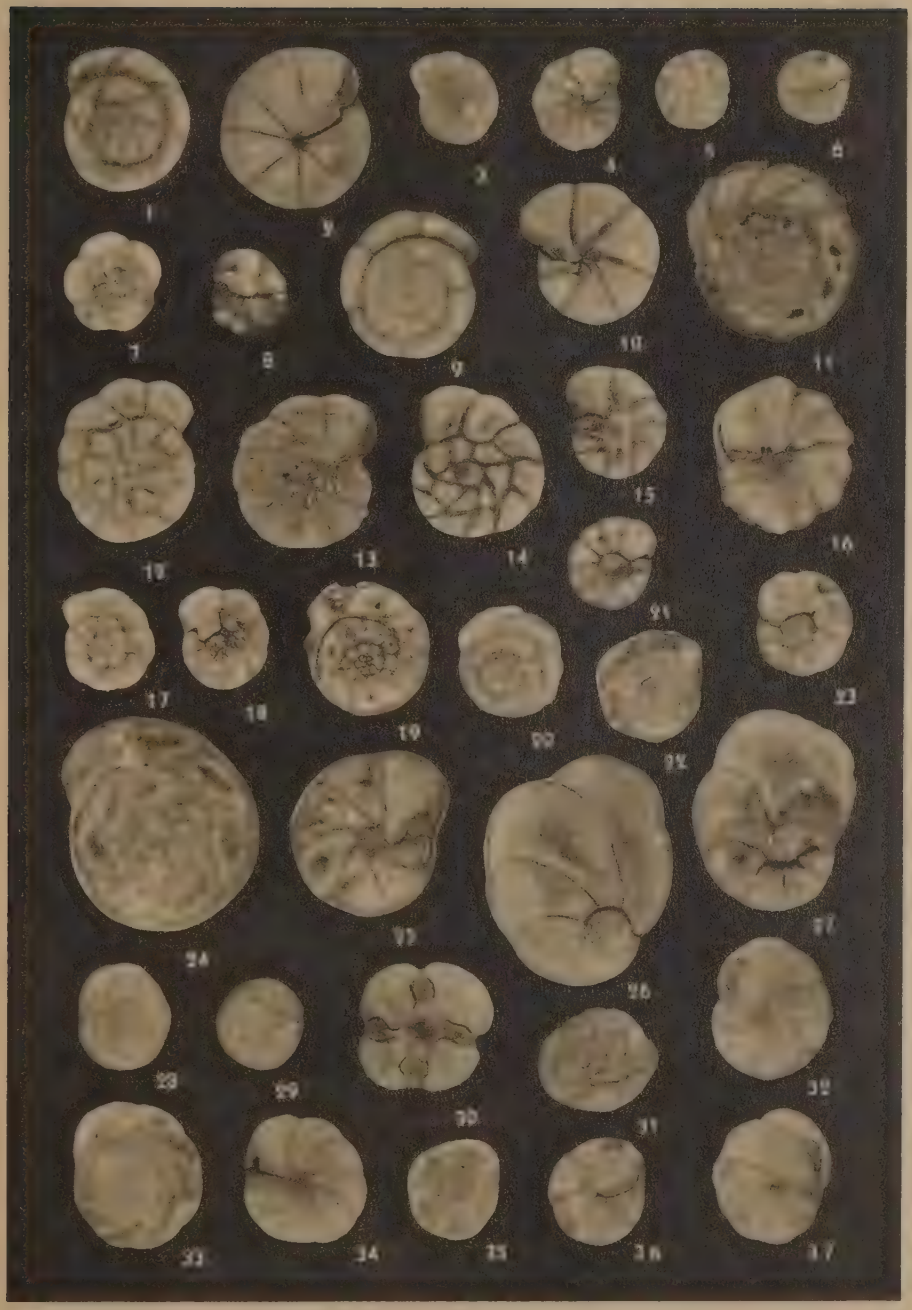


PLATE 10

Figure

1. *Cassidulina crassa* d'Orbigny. X 70. Core 233, sample 82.
2. *Cassidulina curvata* Phleger and Parker. X 70. Core 246, sample 24.
3. *Cassidulina norcrossi australis* Phleger and Parker. X 51. Core 257, sample 86.
4. *Cassidulina subglobosa* H. B. Brady. X 51. Core 284, sample 109.
5. *Cassidulina* sp. 1. X 51. Core 215, sample 46.

6, 7. *Cassidulina reflexa* Galloway and Wissler. X 51. Core 233, (6) sample 128; (7) sample 133.

8. 9. *Cassidulina* sp. 2. (8) X 42. Core 233, sample 132; (9) X 51. Core 233, sample 133.

10, 11. *Cassidulinoides mexicana* (Cushman). X 51. Core 221, sample 56.

12 a, b, 13. *Ehrenbergina trigona* Goës. X 51. (12 a, b) Core 279, sample 23; (13) Core 242, sample 45.

14, 15 a, b, 16. *Ehrenbergina undulata* Parker, n. sp. X 51. (14, 16) Paratypes; (15 a, b) Holotype. Core 290, sample 21.

17, 23. *Rotamorphina laevigata* (Phleger and Parker). X 51. Core 228, sample 16.

18. *Chilostomella oolina* Schwager. X 51. Core 242, sample 19.
19. *Pullenia bulloides* (d'Orbigny). X 51. Core 284, sample 94.
20. *Pullenia quinqueloba* (Reuss). X 51. Core 278, sample 15.
21. *Pullenia* cf. *riveroi* Bermudez. X 51. Core 267, sample 1.
22. *Pullenia* sp. X 51. Core 278, sample 13.

24, 25. *Anomalina balthica* (Schroeter). X 51. Core 221, sample 10.

26, 27, 28. *Anomalina* sp. X 51. Core 234, sample 30.

PLATE 11

Figure

1, 2. *Planulina wuellerstorfi* (Schwager). X 42. Core 290, sample 1.

3, 4. *Planulina ariminensis* d'Orbigny. X 51. Core 290, sample 4.

5, 6. *Laticarinina pauperata* (Parker and Jones). (5) X 42. Core 267, sample 21; (6) X 30. Core 290, sample 1 B.

7, 8. *Cibicides kullenbergi* Parker, n. sp. X 42. (7) Holotype; (8) Paratype. REHOBETH Sta. 3—38.

9, 14. *Cibicides lobatulus* (Walker and Jacob). X 42. Core 221, sample 1.

10, 11. *Cibicides* cf. *refulgens* Montfort. X 51. Core 215, sample 50.

12, 13. *Cibicidina rhodiensis* (Terquem). X 51. Core 215, sample 48.

15, 16, 17. *Cibicides robertsonianus* (H. B. Brady). X 51. (15, 16) Core 217, sample 15; (17) Core 288, sample 38.

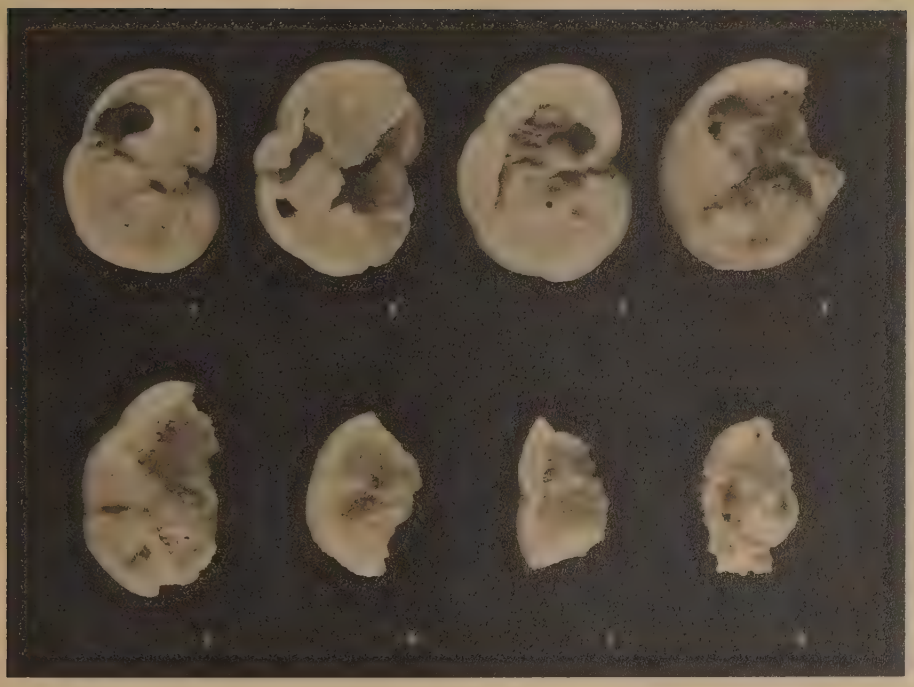
18, 22. *Cibicides* sp. (18) X 51. (22) X 42. Core 288, sample 39.

19. *Rupertia stabilis* Wallich. X 30. Core 290, sample 1 A.

20, 21. *Planorbulina mediterranensis* d'Orbigny. X 51. Core 221, sample 1.

PLATE 12.

Specimens of the *Globorotalia menardii-tumida* group showing solution of calcium carbonate. X 40. (approx.) Photographs are not retouched.



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